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THE

AMERICAN NATURALIST

VOL. XXXIII. *November, 1899.* NO. 395.

THE WINGS OF INSECTS.

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CHAPTER V.

The Development of Wings.

I. FIRST APPEARANCE, POSITION, AND GROWTH OF WINGS.

THE development of wings is one of the many subjects of biologic study which have been first undertaken in their more difficult phases. The internal processes concerned in the making of an insect wing were first studied by Weismann in the Diptera,[1] and in those Diptera in which conditions are most difficult of interpretation. One by one forms of less complexity have been studied, and a rational account of the process of wing development has at length found its way into several text-books. The process is still most fully illustrated, however, by studies of representatives of the two groups which are least typical for insects as a whole, the Diptera and the Lepidoptera. Rehberg's inconclusive paper on wing development in *Blatta*

[1] Weismann, A. *Zeit. wiss. Zool.*, vol. xiv (1864), pp. 187–336.

germanica[1] remains the only considerable attempt to study the making of the wing in an insect with incomplete metamorphosis. In this chapter we give the results of some studies in which we have endeavored to follow the phylogenetic order of wing development.

It is not necessary to trace in this place the steps by which the present state of knowledge of wing development has been reached; for this has been well done by several writers. Among the more complete of these summaries are those of Gonin[2] and of Pratt.[3]

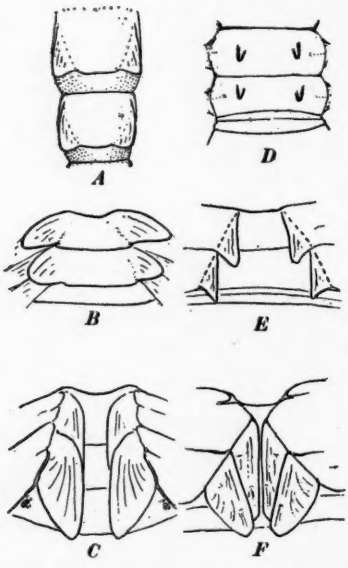

FIG. 82. — Wings of nymphs: *A*, of a stone fly (Capnia); *B* and *C*, of a grasshopper; *D*, *E*, and *F*, of a dragon-fly. In the four lower figures the dorsal half of the body of the nymph is represented as spread out flat. Figures *B* and *E* are from nymphs one third grown; and *C* and *F* from nymphs that were three fifths grown.

Neither does it seem desirable to enter into a detailed discussion of controverted points, our object being merely to state what is definitely known on this subject, and to add the results of some of our own investigations.

It is well known that the wings of insects arise as sac-like folds of the body wall of the second and third thoracic segments. These folds first appear at the point where the suture between the tergum and the pleurum later develops. In most insects with incomplete metamorphosis they are so directly continuous with the tergum and become so solidly chitinized with it that they have generally been interpreted as outgrowths from its caudo-lateral margin (Fig. 82, *A*, *B*).

[1] Rehberg, A. *Jahrb. d. k. Gymn. zu Marienwerder*, 1886.
[2] *Bull. de la Soc. Vaud. des Sci. Nat.*, vol. xxi, pp. 90–98.
[3] *Psyche*, vol. viii (1897), pp. 15–30.

In the Plecoptera, Ephemerida, Hemiptera, Blattidæ, *et al.*, the external changes during growth are comparatively slight — increase in size and internal differentiation, and the development of the veins and of the basal articulations. In the more specialized Orthoptera there occurs the well-known reversal of position of the wings at the last molt. In the Odonata there are the noteworthy differences that the wings arise in an erect position upon the body wall, and at midway the length of their respective segments, and not from the hind margin (Fig. 82, *D*). They appear at a time when the tergum and the pleura are very

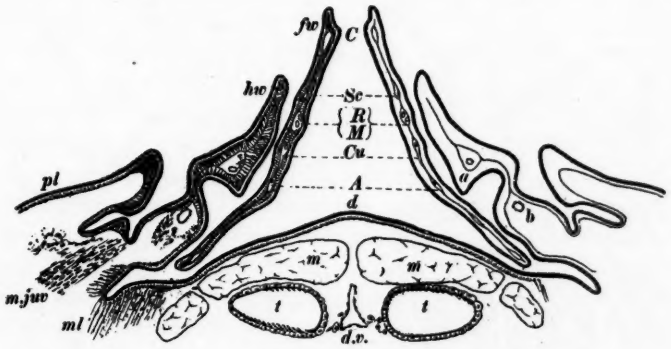

FIG. 83. — Dorsal part of a transverse section of a nymph of *Celithemis elisa*, one third grown: *d*, dorsum; *pl*, pleurum; *d.v.*, dorsal vessel; *t*, *t*, tracheæ; *m*, *m*, muscles in cross-section; *ml*, muscles in longitudinal section; *m.fw*, developing muscle of the wing; *hw*, hind wing; *fw*, fore wing; *a* and *b*, the cut ends of the basal transverse trachea of the hind wing; *C*, costa; *Sc*, subcosta; *RM*, the coalesced radius and media; *Cu*, cubitus; *A*, anal vein.

little chitinized, and are hardly more identified with one than with the other. Later, as in the saltatorial Orthoptera, owing to a rapid growth of the pleura, especially at the wing bases, they are pushed over upon the dorsum and lie in an inverted position (Fig. 82, *E*, *F*), to be righted only at the final transformation.

Fig. 83 shows the relations of parts in a dragon-fly nymph one third grown. It represents a partial cross-section passing through the posterior part of the basal attachments of the hind wings and through the fore wings just before the arculus. In the hind wings are seen (*a*, *b*) the cut ends of the transverse

basal trachea. In the fore wings the tracheæ in the vein cavities are seen in section. The pleura (*pl*) are seen overlying the bases of the wings.

It is interesting to follow the basement membrane of the hypodermis throughout the section, noting how the hypodermal cells are elongated in certain parts, rounding out the sharp

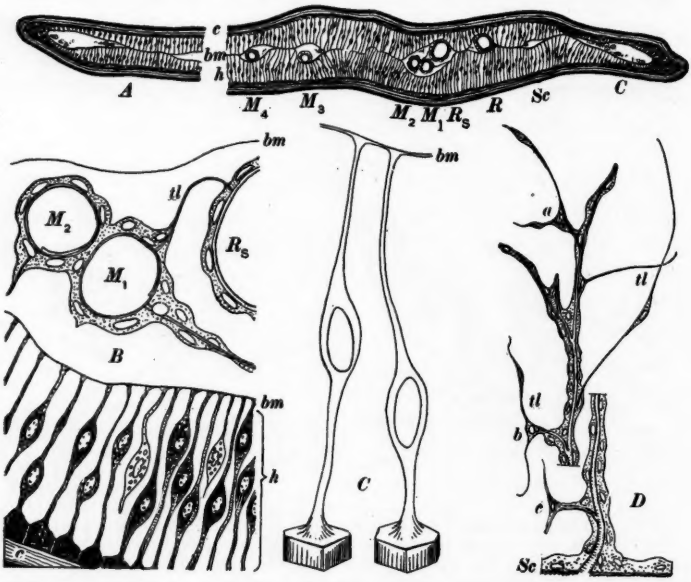

FIG. 84.—*A*, cross-section of a fore wing (in part omitted) of a nymph, two thirds grown, and recently molted, of *Anax junius*; *c*, cuticle; *bm*, basement membrane; *h*, hypodermis; the veins of the wing are designated by the usual lettering. *B*, a small portion of the same, more highly magnified; *tl*, tracheole; *C*, two hypodermal cells from the same; *D*, base and apex of the fifth antecubital trachea, as seen in horizontal section, of another wing of the same specimen; *Sc*, epithelium and intima of one side of subcostal trachea; *a*, *b*, *c*, cells at origin of tracheoles; *tl*, *tl*, tracheoles.

angles of the exterior, and completely occupying the narrower spaces in the wings.

It is also important to note that the basement membrane of the hypodermis of the wing differs in no respect from that of the hypodermis of the body wall, and is continuous with it. In the thinner parts of the wing the two basement membranes meet and fuse, thus forming what has been termed the middle

membrane of the wing. Along certain lines, seen in section in the figure, the two membranes remain separate, and thus are formed the cavities of the wing-veins.

Fig. 84 represents a partial section of a fore wing of a nymph of *Anax junius* two thirds grown; the section was taken at the nodus. The general features here seen are common to the wings of all nymphs—two layers of very elongate, hypodermal cells, which meet in places and form the middle membrane, and remain separate in other places, forming the vein cavities, which usually contain tracheæ. At *B* and *C* in the figure is shown the character of the commoner hypodermal cells.

There is in insects with a complete metamorphosis another type of wing development; this is so different in its external aspects that it may best be described, with respect to these, separately, after which the common fundamental features of wings may be considered.

It has been abundantly shown by others that modification of the type of wing development has kept pace with the increasing complexity of the metamorphosis. The wing-buds are most erratic in the headless, appendageless larvæ of the higher Diptera, Hymenoptera, etc., while they are simplest in larvæ possessing a head, legs, and mouth parts, and especially in those in which the structure is altered least in transforming to imagoes. Among coleopterous larvæ are some in which, save for the appearance of wings, the change is slight; and, indeed, in certain of these (notably the meal worm) specimens are occasionally found with the wings developing externally.

A little coccinellid beetle (*Hippodamia 13-punctata*) has furnished us simpler and more instructive conditions of wing development with complete metamorphosis than have heretofore been fully presented. Fig. 85 shows three early stages in the development of the wings of this insect. Each wing begins as a disk-shaped thickening of the hypodermis (Fig. 85, *A*), which was first observed when the larva was about one fifth grown. A prominent spine, which stands at its dorsal margin, is an excellent landmark to aid in finding it at the first, and when found it is certainly recognized by a slightly concen-

tric arrangement of its cells. It is not at first in connection with nor in approximation to any trachea. The disk elongates and then becomes folded upon itself, thus initiating the wing surfaces. At the time of the folding the wing retreats from the surface, settling down into a pouch-like invagination of the hypodermis (Fig. 85, *C*). Thus it approaches a lateral tracheal trunk, from one of whose smaller branches a few small tracheoles now enter it. As growth continues, the wing extends itself slowly ventrally, as shown in Fig. 86; the mouth of its enveloping pouch becomes somewhat closed by the growth and extension of the pleural hypodermis, but to very various degrees

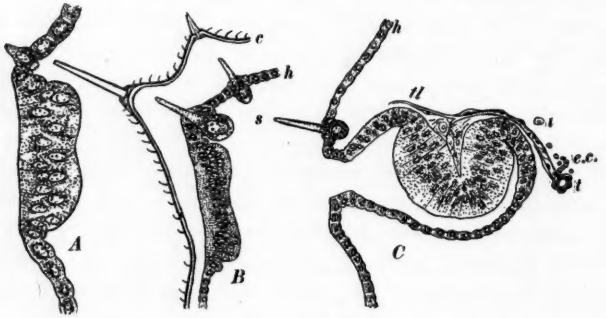

FIG. 85.—Three stages in the early development of wings in *Hippodamia 13-punctata*: *A*, from a larva about one fifth grown; *B* and *C*, from older larvæ, less magnified; *c*, loose cuticle, shown only in *B*; *h*, hypodermis; *s*, spine; *t*, trachea; *tl*, tracheole; *l*, leucocyte; *e.c.*, embryonic cells.

in different specimens, a large part of the larval wing being often found covered exteriorly only by the chitine of the integument.

During the last larval stage the wing is pushed outward and the fold of hypodermis overlying its edges is withdrawn radially, and it emerges from its pouch, becoming greatly extended ventrally under the old larval cuticle, with its walls thrown into numerous folds. When the last larval skin is shed, a still greater expansion transforms it into a wing of the pupa.

Previous to their emergence from the larval wing pockets, there is no appreciable difference between the fore and the hind wings; after this, however, the elytron shows a distinctly

thicker layer of hypodermis on its dorsal side, and the thinness of the hind wings steadily increases with their expansion in area. The hind wings are greatly expanded at the final transformation, while the elytra are almost as large in the pupa as in the imago.

Comparing now the two types of wing development (external and internal), we see that, despite great superficial differences, there are important common features. In both cases the wings arise in early life and form a double plate-like fold of hypodermis, between whose layers tracheæ shortly penetrate. In the former the extension of the wings is gradual and moderate, excepting at the time of transformation; in the latter they early settle down into deep hypodermal pockets, in which their extension is of necessity retarded, although cell multiplication seems not to be.

The principal structural elements which enter into the making of the insect wing are hypodermis, tracheæ, nerves (which, though always mentioned and once or twice figured by other students, we have rarely seen in wings), leucocytes, embryonic cells, and, possibly, sometimes fat cells. Of these, the first two only are essential structures; and these are so important as to merit special treatment.

II. The Origin of the Tracheation of the Wing.

In wings developing externally like those of a dragon-fly one sees the principal tracheæ passing very early out into the wing-bud, branching freely and forming by multitudinous terminal anastomoses a network of capillary tracheoles. In a horizontal section of a nymphal wing one may see how the branches of the tracheæ are formed. Fig. 84, *D*, is from such a section. It will be observed that the terminal tracheoles are intracellular, the tracheæ intercellular; but that there is easy transition from one condition to the other.[1]

In a wing so mounted that the tracheal system is filled with

[1] There are no such distinct transition cells between tracheæ and tracheoles as Holmgren found (*Anat. Anz.*, vol. xi, pp. 340–346) in the spinning glands of caterpillars, although the cells at *a*, *b*, *c* might seem to stand in the same relation.

air it is easy to see everywhere anastomoses between the distal ends of the tracheoles. This is not shown in our figure; indeed, it is difficult to see it in sections anywhere. The walls of the tracheoles are of extreme tenuity; the best of chitine stains leave them untouched; they are probably protoplasmic tubes at their extremities, such as would best subserve the respiratory process. Tracheoles of this type are everywhere relatively short.

In the much discussed tracheation of the lepidopterous larval wing there are the two well-known systems: the temporary

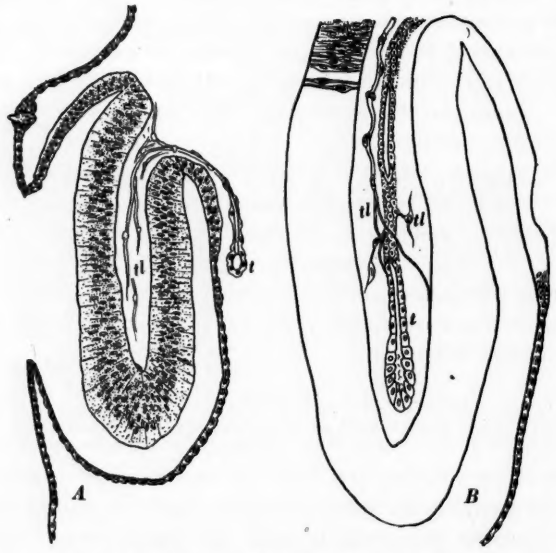

FIG. 86. — Wings of *Hippodamia 13-punctata*, two stages later than those shown in Fig. 85: *t*, *t*, tracheæ; *tl*, *tl*, tracheoles.

system of tracheoles, which enter the wing in the penultimate larval stage and which are functional in the last larval stage; and the permanent wing tracheæ, which grow out into the wings in the last larval stage, but do not become functional until pupation, when they have acquired terminal and lateral tracheoles of their own. In each case the developing air-vessels arise from the epithelium of the lateral tracheal trunk; but they do not communicate with the lumen of this trachea

till after a molt, their mouths being closed at first by the pre-existing intima of this trachea. Fig. 86, *B*, will show clearly that in beetles we have the same conditions, though here the temporary system is much less highly developed. This is from a well-grown larva; *tl* is a tracheole; only such are present in the younger wing shown at *A* in this figure; *t* is a developing trachea; and *tl*, *tl* are developing tracheoles attached to single cells of the wall of the trachea.

We believe that this peculiar temporary system of tracheoles is due to and dependent upon the retention of the wing within the narrow limits of its hypodermal pouch; for its small size alone renders its aëration by simple tracheoles possible. We believe that this also explains the retarded development of the tracheæ. In an externally developing wing it is necessary that the tracheæ should grow with the wing, in order to carry the tracheoles out within reach of the tissues; but when a wing develops internally its length for a long time does not exceed the length of normal tracheoles. In such a wing the tracheæ develop only when needed — at the approach of the time when rapid extension is to take place.

III. The Behavior of the Hypodermis.

The cells of the hypodermis are remarkable, not only for their secretory and excretory activity, but also for their capacity for rapid shifting and readjustment. Their life history is one of alternating conditions: first, growth beneath a limiting layer of chitine; then, sudden lateral extension when the chitine is thrown off at molting.

The typical hypodermis of prismatic hexagonal cells is found only where the body wall is smooth; in short curves and angles, and in folds of the integument, and in the wings where close crowding is followed by enormous expansion their change of form is very great. At their ends, however, these cells maintain fairly constant relations. Externally they must needs cover the surface to provide its integument, internally they join the basement membrane; between these two planes, however, they may assume almost any shape, according to the conditions of

their growth. Their commoner forms are shown in the figures presented herewith.

The basement membrane consists, we believe, of the fused inner ends of the hypodermal cells or of processes from them. It is often incomplete or fenestrated, and it is of extreme tenuity. Semper thought it (in the Lepidoptera) composed of leucocytes applied to the free inner ends of the hypodermal

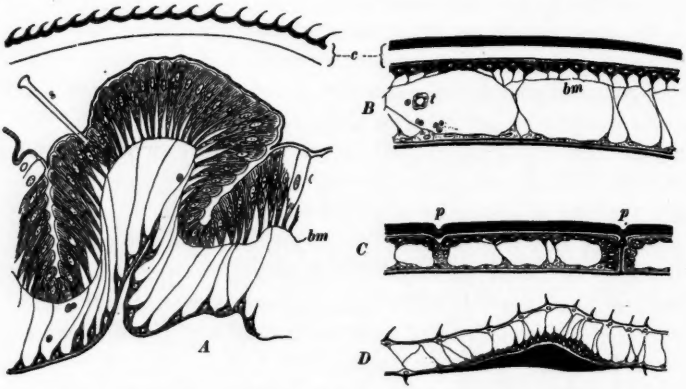

FIG. 87. — Sections of wings of *Hippodamia 13-punctata*, all drawn to the same scale: *A*, from full-grown quiescent larva, a bit of the wing crumpled under the loose larval cuticle; *s*, a deciduous spinule; *bm*, basement membrane; *B*, fore wing (elytron) of an old pupa; *C*, fore wing of a newly transformed imago; *p*, pits above the chitinous pillars; *D*, hind wing of a newly transformed imago, showing especially the manner of formation of a special chitinous brace.

cells, and his opinion has been concurred in by several subsequent investigators; but we are inclined to believe that in the forms we have studied, the formation of it from leucocytes is at least exceptional, for the following considerations: —

1. While leucocytes are not infrequently seen lying against it, we have seen no direct evidence of their participation in its development.

2. During early stages it is well formed and *destitute of nuclei.*

3. In later stages, when, after the expansion of the wing, it contains distinct nuclei, there is evidence that some of these at least are derived from the hypoderm cells whose nuclei, once crowded up to this level, have remained stranded there after the expansion of the wing.

In past accounts of hypodermal development in wings too little attention has been paid to the mechanics of the developmental process—to the varied conditions under which the cells labor in successive stages. To these conditions are mainly due the different cell forms seen; and, except where like conditions are compared, different series will be contradictory. A study of hypodermal ontogeny in the wings of representatives of half a dozen orders of insects convinces us that it is impossible to summarize the process except in the most general terms.

In very early stages in externally developing wings there is found a condition of the hypodermis not far removed from the normal. The cells are only a little less prismatic, a little more columnar or rhomboidal, and the two layers meet internally in very limited tracts. Fig. 89, *A*, is from the wing of a young acridid nymph. It would answer almost equally well for a

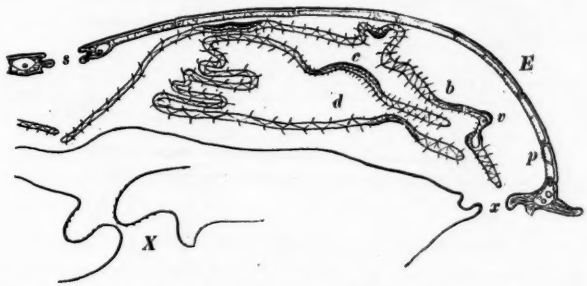

FIG. 88. — Cross-section of wings of a newly transformed imago of *Hippodamia 13-punctata*, *in situ*: *E*, fore wing; *b*, basal portion of hind wing; *d*, distal, reflexed portion of hind wing; *s*, elytral suture; *v*, a vein; *c*, a cuticular thickening; *p*, stridulating (?) processes; *x*, the interlocking ridges, seen more magnified at *X*.

young nymph of the dragon-fly, Gomphus, or for several ephemerids we have studied; or, for that matter, for parts of the ephemerid tracheal gill or for its operculum; or, save for the lack of tracheæ, for the overlapping edge of the prothorax or for a section of the labium.

This early condition is followed by a long period of growth, during which the hypodermal cells become crowded and much more elongated, their nuclei, which were originally nearer their inner ends, coming to occupy a spindle-shaped middle portion in the cells (Fig. 84). The crowding is excessive, and the effect

of it in massing the cells much more marked, of course, when wings are developed internally. But even here the spindle-form cell is recognizable (Fig. 86, *B*), and all the cells appear still to extend from surface to surface of the hypodermis.

The first great expansion of the wing occurs just before pupation, with insects having complete metamorphosis, but not until the final transformation, with those in which the metamorphosis is incomplete. This expansion results in the broadening of the bases of the hypodermal cells, in the settling down of their nuclei close upon the chitine layer, and in the drawing out of their inner ends into a long, slender prolongation, which

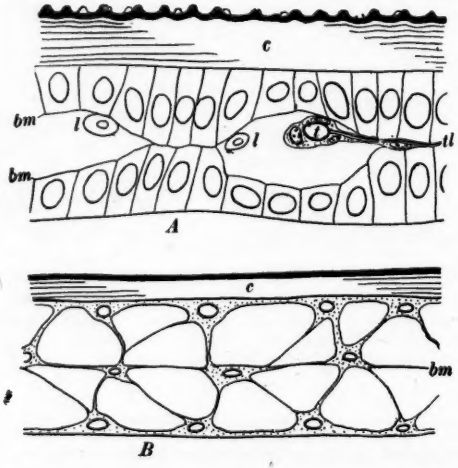

FIG. 89. — *A*, cross-section of the wing of a young acridid nymph: *c*, cuticle; *bm*, *bm*, basement membrane; *t*, trachea; *tl*, tracheole; *l*, leucocyte; *B*, stellate cells in hypodermis, from the anal angle of a wing shown in Fig. 83.

generally retains its attachment to the basement membrane, and thus to its neighbors opposite, in those portions of the wings where the membranes are united. The cells thus become peaked in appearance. Their breadth and height will depend, however, on (1) the extent of the previous crowding; (2) the extent of the surface they are now called upon to cover; and (3) the width of the space they are now called upon to bridge. When, through excessive crowding, some of the innermost

nuclei have come into contact with the basement membrane at the subsequent expansion of the wing, these, instead of retreating with their fellows to the chitine layer, seem instead to remain where they are, and to attract to themselves the slender prolongations of the neighboring cells. They thus acquire a stellate appearance, as shown in Figs. 89, *B*, and 90, *D*. These seem to occur only in narrow spaces, in which great expansion has followed close crowding.[1] We have found them in Leucorhinia (Fig. 83) in the rapidly expanding anal angle of a wing, the greater part of which appeared as Fig. 84, *B*, the cells having spindle-shaped bodies. We have seen them also in the anal angle of the wing of a pupa of Corydalis,

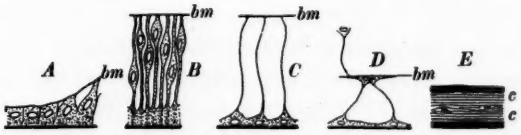

FIG. 90. — Diagram illustrating the behavior of the hypodermis during the development of an insect wing: *A*, nearly normal hypodermis; *B*, the same, after being crowded within the wing fold; *C*, the same after the first great expansion of the wing; *D*, a cell stranded upon the basement membrane; *E*, disappearance of the hypodermal cells with chitine formation.

the pre-anal area being filled with the peaked cells more characteristic of that stage.

The segregation of the hypodermis, which results in the accumulation of it around the tracheal channels and in those parts of the wing to be made strong by heavy deposits of chitine, takes place during the final stages. Some interesting illustrations of it are shown in Figs. 87 and 88, and are explained in the legends to the figures. These processes and the final disappearance of the scattered hypodermal cells, wasting themselves away in chitine formation, are the final steps in the making of the wing.

The accompanying diagram (Fig. 90) will, therefore, represent what we think may fairly be taken as typical for the behavior of the hypodermis. While this strongly suggests

[1] This is the "Grundmembrane" of Semper, which was believed by him to be formed by leucocytes during the pupal period, and, therefore, to be distinct from the middle membrane of the wing of the larva.

ontogeny, we desire explicitly to state that we believe these changes to accompany certain conditions under which cells are placed, rather than any particular stages.

IV. THE TRACHEÆ AND THE HYPODERMIS.

After discussing these two separately, there remain a few interesting features of their correlated behavior to be noticed.

In all insect wings the two plates of hypodermis constituting the wing fold are at first separate, *i.e.*, not fused internally. At the time when the tracheæ enter the fold the two layers become approximated along lines midway between the tracheæ, resulting in actual fusion of the internal ends of the cells. We have already shown in Psocus[1] (and have seen in several other insects) the external evidences of the gradual lateral extension of the fused area to delimit definitely the channel through which the tracheæ pass. The term "cuticular thickenings" has been used hitherto to designate the pale bands along the tracheæ, and the veins to be formed here will be, of course, cuticular thickenings; but until the veins are formed (and this does not occur until the final molting) the term is inaccurate and misleading. A glance at Fig. 84, *A*, will discover that the hypodermis is in the earlier stages actually thinner here than elsewhere. It is only at transformation to the imago that the cells become aggregated about these channels and form there the dense chitine of the veins. The pale color of the bands, indicating the extent of the vein cavities when viewed by transmitted light, is doubtless due to the fact that the hæmolymph filling these cavities is more translucent than the hypodermal tissue which completely fills the wing elsewhere.

But, returning to the earlier stages, we have seen that, in wings developing externally, the hypodermis encloses the tracheæ in channels which ultimately become veins. It is now to be noted that there are often channels present which do not contain tracheæ. This is oftenest true of two large channels at the lateral margins of the wing (Fig. 84, *A*). Of these the costal remains abundantly lined with cells, which

[1] *American Naturalist*, vol. xxxii, p. 241, Figs. 11, 12.

ultimately form the strong costal vein. Its trachea is often atrophied, probably owing to the disadvantageous position of its base in relation to air supply, as we have hitherto indicated. The anal channel becomes obliterated, and the dense hypodermis of its walls dispersed by subsequent expansion of this part of the wing. In some wings in which this space persists, as in Psocus, it is occupied by the third anal trachea.

In wings developing within small hypodermal pockets, while the cells are densely crowded and while the fusion of the cells internally joining the two layers is more tardy and incomplete, the same principal channels are formed. In the Lepidoptera, though the development of their tracheæ is retarded, the temporary tracheoles pass out in tangled skeins through the original channels.

But the process of reduction of tracheæ, already begun in the lower orders, finds favorable conditions for progress in the shorter and more open wing sacs developed internally; and we find in all but the more generalized members of certain orders that the close correspondence between tracheæ and channels due to simultaneous development is again lost. Illustrations have been abundantly offered in preceding chapters; we are here offering only a suggestion as to the reason, first for this correspondence, and then for the loss of it. While the tracheæ seem at first to have been the determining factor in the venation, and while we have been able to show a gratifyingly large number of cases in which the tracheæ show the unmistakable signs of homology, and cases in which the course of the veins is still determined by them, it appears that in certain insects the tendency of the hypodermis to segregate itself and to form chitine along certain lines has become so well established as to be more or less completely independent of the tracheæ. The veins have to do in these cases with locomotion in adult life; the tracheæ, with growth and metamorphosis. The adult wing, whatever it may have been originally, has become a dry resilient plate of chitine traversed by finely adjusted supports. It would be manifestly disadvantageous for the tracheæ to follow the course of these supports, sharp angled, and often recurrent; but in wings with slight fusion between

the walls this is unnecessary. The disappearance of distinct tracheal channels has restored open competition between the tracheæ, which accounts for the more rapid disappearance of all save those most favorably situated in relation to the source of the air supply — usually only two in the most specialized insects, which still stand as representatives of the two groups of tracheæ with which we begin our series.

Fortunately for the study of homologies in insect wings, the veins had attained an arrangement so useful that it could be held by natural selection after the tracheæ had ceased to determine their position.

A CONTRIBUTION TO THE MORPHOLOGY OF PENNARIA TIARELLA McCRADY.

MARTIN SMALLWOOD.

THE following paper was undertaken at the suggestion of Dr. Charles W. Hargitt, to whose kindly criticism and suggestions I am under special obligations. I am also under obligations to Dr. C. O. Whitman for courtesies at the Marine Biological Laboratory, where in part the work was done.

The purpose of the paper is an investigation of the more fundamental morphological features of this hydroid, and the development of the Medusa and origin of the sex cells.

In the work of former students of the Pennaridæ of the United States little attention was directed to other than external characters and classification. The early contribution of McCrady (10) contains the best general account that has been given of this species. L. Agassiz's (1) description of *P. gibbosa* is equally excellent for that species; yet in neither is there any reference to features of structure, which have later assumed a degree of importance not then recognized.

Methods. — For killing and staining a variety of methods was tried, but those more generally familiar gave usually the best results. Fresh Pennaria were immersed at once in corrosive-acetic, picro-acetic, Kleinenberg, and Perenyi's fluid. The best results were obtained from corrosive-acetic and picro-acetic. An excellent differential stain was secured by staining *in toto* and then extracting with acid-alcohol. Borax carmine was found to be the best stain with material fixed in picro-acetic. There seemed to be no choice of clearing agents, either xylol or turpentine was satisfactory. Excellent whole mounts of the hydroid were made by staining for a considerable time — two days — in borax carmine, then extracting with acid-alcohol. The specimens were next cleared in clove or cedar oil for

several hours. By this process the cells could be distinguished easily in any part of the hydroid where the perisarc was not too dense.

If the parts of the colony are taken up in detail, they will be found to agree on the whole with the account of Pennaridæ given by L. Agassiz (1). The main stem arises from the hydrorhiza by a slightly geniculate course, giving off branches alternately at each bend. These branches may again divide. Each branch gradually tapers from the base, bearing on the end a single hydranth of large size. About the origin of a branch there are several annulations, from eight to twelve, and several on the branch itself near its origin. Around the base of the hydranth, which is more or less bottle-shaped,—the neck of the bottle corresponding to the distal end of the hydranth,—there is a row of tentacles, twelve in number. These tentacles round off at the end much the same as in all Tubularidæ. They are termed the "long tentacles" to distinguish them from the "short tentacles," which are more or less irregularly arranged around the oral end of the hydranth. These latter are much shorter than the long tentacles, and are arranged in two whorls. They are terminated by a knob, or globular tip, which is supplied with numerous nematocysts. There is a great deal of variation in the number of the short tentacles, due chiefly to the age of the hydranth; the older hydranth having the most. The Medusæ arise from the hydranth anywhere between the rows of tentacles. They are in direct communication with the body cavity until nearly mature, when the connection becomes closed and the Medusæ are set free.

HISTOLOGY OF PARTS.

Hydrorhiza. — There will be found in the hydrorhiza a very dense, hard perisarc on the upper surface. It is more than twice as thick here as on the opposite side and much denser. The ectoderm upon this surface of the hydrorhiza presents an almost structureless appearance. It is chiefly made up of very fine granules of protoplasm. There are scattered around in this space occupied by the ectoderm several rather large oval or

roundish bodies. In their reactions to stains they show that they are probably the nuclei of the ectodermal cells. The protoplasm is more or less vacuolated; large, round vacuoles occurring scattered through it. This is especially noticeable in older hydrorhiza. In part, the appearance of all the tissues will depend largely upon the age. A young hydrorhiza differs from an old one in the degree to which degeneration of the parts has gone. On the lower side, or side adhering to the substratum, the ectoderm is only distinguishable as a narrow layer in which there are a few scattered granules. Otherwise it appears to be structureless. It is not more than one fourth as thick here as it is on the upper side. In the young hydrorhiza, which is creeping over the eel-grass, the ectoderm contains cells which are very similar to the cells in the endoderm. The same is also true of the ectoderm in the upper side during this stage. The endoderm exhibits a cellular structure, although the cell walls are very indistinct. The cytoplasm has been broken up into small, round bodies, and the nuclei are much smaller here than elsewhere in the endoderm of the hydroid.

Hydrocaulus.—The perisarc in section in a young hydrocaulus is semi-transparent or opaque. It is thicker than when mature. In the mature hydrocaulus the perisarc is thinner, and is darker adjacent to the ectoderm than in the hydrorhiza. The ectoderm shows signs of cellular structure in the position of the nuclei and the presence of cell walls in places. As the hydrocaulus is examined nearer the hydranth the nuclei are found to belong to definite cells with definite cell walls. If the endoderm is examined in a typical section, it is very materially different from the endoderm in the hydrorhiza. The nuclei are larger and more prominent. The cytoplasm is homogeneous except for the presence of food particles.

Hydranth.—The hydranth is wholly devoid of perisarc, which terminates somewhat abruptly just below it. The cells of the ectoderm possess distinct nuclei and cell walls, but only a small amount of cell substance, judged by the reaction to stain. The cells of the endoderm are arranged in the hydranth in groups, usually there are four of them. The most conspicuous of these are the digestive cells. They are much larger than the other

cells of the endoderm, and project out into the cavity about half of their length. The nuclei are of different sizes, according to their position in the endoderm. Some of the nuclei found in the digestive cells are twice as large as those occurring in the other cells. Between these four groups of specialized digestive cells the endoderm is quite regular.

Mesoglea. — The mesoglea presented the same appearance and was of the same thickness in each region.

ORIGIN AND DEVELOPMENT OF THE MEDUSA.

The Medusa takes its origin from the hydranth, between the rows of tentacles. There is no definite region on the hydranth from which the buds arise. However, they are more abundant near the base of the second or "longer tentacles." The number of buds which may be found upon the hydranth at one time varies. In case the hydranth is giving origin to male Medusæ there may be four or five, but usually two or three are all that will be found. The hydranths which give rise to female Medusæ generally give off only one. One exception was noted to this, but it holds true in the majority of cases. When a hydranth gives origin to more than one Medusa, they will not be in the same stage of development. I have found the two extremes on the same hydranth — the buds just forming and the mature Medusæ ready to be set free, together with several intermediate stages.

The Medusa bud arises as a simple evagination of the hydranth. The bud is hollow and supplied directly with nourishment from the circulating currents of the hydranth. As a bud becomes larger and longer, many interesting changes take place. In the mature Medusa the parts correspond to the type Hydromedusa, yet the manner in which the several layers originate is very different. Agassiz states that Pennaria develops its Medusæ in the same way as Coryne and Bougainvillia do (2). While the several parts are the same in Coryne and Pennaria, yet their origin and development are very different. The first sign of the formation of the Medusa bud is shown by a thickening of the cells of the ectoderm. This change produces a

slight papilla-like elevation on the side of the hydranth. The endoderm goes through a similar process, though not so extensive. There is no open cavity in the bud at this stage (Fig. 1). The space is entirely filled by the cells of the endoderm. The cells of the ectoderm have changed in appearance very much from those adjacent to them in the hydranth proper. These cells are the chief seat of activity, as all of the more important changes, which occur from now on, take place in them. The cells of the endoderm are secondary in importance. These results are confirmatory of the work of Dr. F. Braun (3) and contrary to that of Arthur Lang (4). The cellular structure in the ectoderm has practically disappeared at this early stage, and we have a large number of nuclei scattered in the cytoplasm. These nuclei are large and prominent. They are nearly spherical in shape. There is a very definite nucleolus, usually centrally located, which stains very deeply. The nucleoplasm has a few chromatin fibres irregularly arranged. This condition of the ectoderm is brought about in the following manner. The ectoderm, more especially at the distal end, begins to grow by a proliferation of cells, so that the thickening of the ectoderm, which takes place in the first stages in the development of the Medusa, is not so much a thickening as it is an increase in the number of cells in this region. The bud begins now to elongate until it has become partly differentiated from the hydranth (Fig. 2). The endodermal cells are smaller than at the earlier stage and enclose a cavity. The proliferation of the cells of the ectoderm continues until the bud has become about half full. It would be more accurate to say that the nuclei become more numerous than that the cells increase, because there is no indication of cells other than the presence of the nuclei and the cytoplasm in which they are imbedded. This may, however, be due to the fact that an absence of cell membrane makes difficult and indistinct the cell boundaries. While this change has been taking place, the Medusa has grown larger and longer. The

FIG. 1.

FIG. 2.

filling up of the distal end of the bud with these prominent nuclei and the surrounding cytoplasm at first forces the endoderm back, but it soon begins to force its way down through these cells in the center and around the margin of the bell. The prolongation of the cells which grow down in the center is to become the manubrium. Jointly with this formation, the endoderm is sending a layer of cells around the bell close to the ectoderm (Fig. 3). As these cells grow around, they cut off the interior mass of ectodermal cells from the outside layer, as shown in Fig. 4. This layer of endoderm now becomes the second layer in the umbrella of the Medusa. All of the cells between the manubrium and this new layer are of ectodermal origin. The cells adjacent to this layer of endoderm show a tendency to arrange themselves in a row, the nuclei of which are smaller than those from which they have been derived. By the time the endoderm has grown around, completely separating the outer layer of ectoderm from the cells within, this row of cells has become a definite layer. This layer becomes now the lining of the bell. When the layer is completely formed, the nuclei are much smaller than they were when the layer was forming. This larger layer is more prominent in *P. cavolini;* the cells are larger and the nuclei more numerous. The mass of cells formed between the bell and the manubrium is to give rise to the

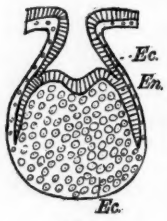

FIG. 3.

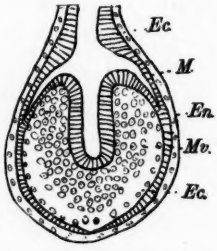

FIG. 4.

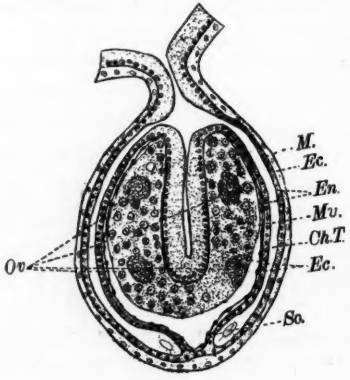

FIG. 5.

reproductive elements. Another layer is yet to be formed. As the reproductive elements continue to develop, a thin delicate membrane is produced which seems to be a differentiation from these cells (see Fig. 5). In the male it is always very delicate, while in the female it becomes more prominent. The manubrium has grown through the cells of the ectoderm while these other changes have been going on, and divides them into two equal parts when seen in section. The cells of the manubrium become differentiated until they present the same appearance as the endodermal cells in the hydranth. The cells of the endoderm which form the second layer of the bell undergo the following changes: the endoderm becomes much thicker in four regions equally distant from each other. This thickening gives rise to the chymiferous tubes by a process of cleavage and not by a fusion of two layers, as is the usual way. The splitting begins at the point where the endoderm turns in from the bell to form the manubrium (Figs. 4 and 6). This process is continued until there is a canal extending down to the lower margin of the Medusa. It is much larger at the lower end and extends farther around than do those same canals halfway up. The endoderm between the chymiferous tubes has not undergone any perceptible change during their growth. In *P. cavolini* the chymiferous tubes are much larger than in *P. tiarella*, probably because they are functional for a longer time. In this hydroid the Medusæ are not set free and these tubes are still found in the mature Medusa.

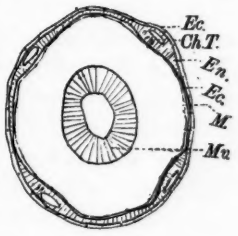

FIG. 6.

The tentacles are rudimentary and never develop. They consist simply in a thickening of the outer layer of the ectoderm. They are found at the end of the chymiferous tubes and are four in number.

The sense organs originate from the endoderm at the blind end of the chymiferous tubes. They do not show any very definite structure. In one there could be distinguished a central portion, which was more transparent than the rest, and

it did not stain so deeply. Many fine filamentous threads extended from the sense body to the walls of the tube. These threads seem to suspend it in the center. The fact that they are in such a rudimentary condition, and less highly specialized than in other Medusæ, would tend to show that their function is of a simple character, possibly used more as balancing organs than anything else. After the chymiferous tubes are formed, the further changes which take place are chiefly confined to the reproductive elements and will be explained in speaking of their development.

The description of the external morphology of the Medusa has been given so accurately by Agassiz that we can do no better than quote his exact words: "The Medusa of *P. tiarella* is one of the most remarkable of our naked-eyed Medusæ. As in the Sarsiadæ, the Medusa bud is formed among the tentacles. The chymiferous tubes never have the extraordinary thickness which is noted in Sarsia, and the cavity of the bell is hollowed out at an earlier period; the Medusa bud gradually becomes more elongated, and when mature is about one-sixteenth of an inch long." The Medusa full of eggs measures 1.2 mm. long and .7 mm. wide. Free of eggs, .9 mm. long and .5 mm. wide. He continues by saying that "the walls of the spherosome are so thin that the Medusa will often assume a quadrangular or octagonal outline with deep indentations between the chymiferous tubes. Large white eggs fill the cavity of the bell; as they increase in size they give the Medusa an opaque milky appearance. The walls of the spherosome become thinner and thinner, and when the Medusa bud has attained its full development and is ready to be separated, the walls become so thin that the Medusa is almost always distorted, either on one side or the other, by bunches of spermaries or by the eggs which have reached such a great size that four or five of them completely fill the inner cavity." The eggs are large white bodies, very opaque, .33 mm. in diameter. When they begin to segment, they look much whiter, and one can distinguish the segmenting egg by the unaided eye (2).

The opening through which the reproductive elements are to be expelled is formed after the Medusa is mature. More obser-

vations upon the Medusæ will be necessary after they become free, in order to ascertain whether a true mouth is formed. In the layers of the mature Medusa there is scarcely any cellular structure evident. The cytoplasm in the cell has disappeared, and the only structural feature present is a round body, which stains very deeply and looks as if it might be a nucleus in a very reduced condition. The chymiferous tubes have entirely disappeared except where the sense organs are found. That these tubes are functional in some of the earlier stages seems reasonably sure, because food has been found in them which was of the same character as that found in the hydranth. The connection between the hydranth and the Medusa becomes reduced with the growth of the Medusa, and finally breaks when the conditions are favorable.

The Medusæ of Pennaria seem to be in a degenerate condition, and in a sense occupy an intermediate stage between the free-swimming Medusæ and those that have lost all resemblance to this stage and are never free, as in Clava, Eudendrium, and others. The two most important reasons for thinking the Pennaria Medusæ degenerate are: first, the change which the chymiferous tubes undergo; and, second, the fact that there is no apparent mouth or circumferential canal. While the evidence is not conclusive, yet it is very suggestive and may throw some light upon other forms.

Oögenesis.

While considering the development of the Medusa, it was stated that the cells originating from the ectoderm, and which filled up the cavity between the manubrium and the bell, were destined to give rise to the reproductive elements.

If the cells are studied in such stages as are represented by Figs. 3 and 4, they will be found to be large and to possess large prominent nuclei. These cells continue to enlarge for a time, during which the cytoplasm becomes denser and more granular close to the nuclei. These may all be considered primitive ova at this stage. Five or six of these, at the most, are all that may mature into eggs. If the various cells

are carefully scrutinized at this period, it will be observed that some of them have more cytoplasm than the adjacent cells (Fig. 5). These few cells, which I have termed ova centers, become mature by the continuous increase of the cytoplasm, which is accomplished by the thrusting out of protoplasmic processes which surround the adjacent cells and absorb them into the developing egg (11). The nucleus appears to be in a state of degeneration in most of the cells adjacent to the egg. Some of the nuclei have their membrane only, while others retain all of the parts of the nucleus even after they have been taken into the egg (Fig. 7). Here some cells have just been taken into the main mass of cytoplasm. The various stages in the degeneration of the nucleus are also evident. Not all of the primitive ova are thus consumed; some will be found which have not been utilized at all. They have simply remained undeveloped and are found scattered among the mature eggs. They seem not to serve any purpose in egg formation, but represent remnants of undeveloped and unused cells.

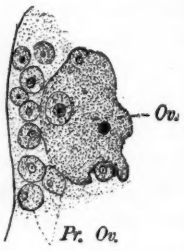

FIG. 7.

LITERATURE.

1. L. AGASSIZ. Contrib. Nat. Hist. North America.
2. A. AGASSIZ. North American Acalephæ.
3. F. BRAUN. *Biologisches Centralblatt.* 1894.
4. ALBERT LANG. *Biologisches Centralblatt.* 1894.
5. KORSCHELT AND HEIDER. Invertebrate Embryology.
6. LANG. Comparative Anatomy. Pt. i.
7. HARGITT AND OSBORN. *American Naturalist.* January, 1894.
8. S. F. HICKSON. *Quar. Journ. Micr. Sci.* Vol. xxxii.
9. VARENNE. Les Polypes Hydraires.
10. MCCRADY. *Proc. Elliott Soc. Nat. Hist.* Vol. i. 1857.
11. DOFLEIN. Die Eibildung bei Tubularia. *Zeit. f. wiss. Zool.* Bd. lxii, p. 61, etc.

REVERSAL OF CLEAVAGE IN ANCYLUS.

SAMUEL J. HOLMES.

THE fact discovered by Crampton that in Physa, a genus of sinistral gasteropods, the direction of the early divisions of the ovum is just the reverse of the corresponding cleavages in the dextral forms suggests, as Crampton pointed out, that there may be some correlation between the reversed cleavage of the ovum and the reversed asymmetry of the adult. The reversed asymmetry of Physa is shown, not merely by the sinistral coil of the shell, but also by the arrangement of the organs of the body. In most gasteropods the anal and genital orifices open on the right side of the body, but in Physa their position is on the left side; and the lung cavity, normally on the right side in the pulmonates, opens on the left in Physa. In fact, the asymmetry of the sinistral form seems in all respects just the reverse of that of the dextral forms. In Planorbis, a genus in which there is a reversal of the position of the organs of the body, although the shell is often coiled in one plane or even dextral (pseudo-dextral), the cleavage of the ovum is of the same reversed type as in Physa. This reversal is shown as early as the second cleavage of the egg which leads to the four-cell stage. Even before there is any elongation of the dividing cell, or any external indication of cleavage whatever, the direction of the approaching division is shown by the inclination of the nuclear spindles. This early indication of the direction of division is shown in the two-cell stage in Crepidula, Limax, Lymnea, and Amphitrite, but in all these cases in which the cleavage is of the dexiotropic or normal type the inclination of the spindles is the reverse of that in Physa and Planorbis. As a consequence of this oblique division, we have probably in all forms with typical spiral cleavage a four-cell stage in which two of the cells lie at a somewhat lower level than the other two and meet in a cross furrow at the vegetal pole. The lower

part of the first cleavage plane, when viewed from the animal pole, bends at this cross furrow in the dextral forms, first to the right and then to the left; in the sinistral forms the bend is first to the left and then to the right. When we know, therefore, between which cells the first cleavage plane runs, the four-cell stage, produced by reversed cleavage, can be distinguished at a glance from a four-cell stage of the normal type. The one is the mirrored image of the other.

It is a remarkable fact that, not only in all dextrally coiled gasteropods whose cleavage has been carefully studied, but in many groups characterized by a typical bilateral symmetry, such as the lamellibranchs, Amphineura, annelids, and polyclades, the cleavage is uniformly dexiotropic. The two sinistral gasteropods, Physa and Planorbis, form, I believe, the only instances in which, up to the present time, a reversed spiral cleavage is known to occur.

It was with the desire of obtaining more data bearing upon this subject that I was led to study the cleavage of Ancylus, the common fresh-water limpet. In this genus the coil of the shell is almost entirely lost, and in some forms the shell appears to possess an almost perfect bilateral symmetry; but in many species of the genus the animal is truly sinistral, as the heart, lung, and anal and genital openings lie on the left side of the body. The genus contains both dextral and sinistral forms and has been divided into several subgenera, Ancylus proper containing the sinistral species, while the subgenus Acroloxus comprises only those that are dextral. The species studied, *Ancylus rivularis* Say, belongs to the sinistral group and is found in considerable abundance in a small lake near Ann Arbor, Mich. Specimens taken September 12, and kept in glass dishes in the laboratory, deposited eggs in the sides of the vessel, but not in any great number. The eggs are laid in minute, transparent, colorless capsules, each capsule, unlike that of the European species *A. fluviatilis*, containing but a single egg. The capsule is covered by a membrane and contains a semi-fluid, gelatinous substance in which the egg floats similar to that which surrounds the egg of Physa or Lymnea. It is a difficult matter, on account of its small size and the toughness of the membrane,

to get the egg out of the capsule without injury, and the chance of losing it in the process of fixation, staining, etc., before it is safely mounted, is very considerable, so that no attempt was made to carry the cleavage very far. At the first cleavage the egg divides into two equal cells, which round off in the usual manner and then become more closely approximated shortly before the division into four cells. The eight-cell stage is formed by the unequal division of the four cells, each cell giving off a smaller clear cell at the animal pole. This cleavage is an oblique one, the daughter cells lying in the angles between the larger cells. The smaller cells do not lie exactly midway between the larger ones, but more nearly over the cells from which they arose. The next cleavage takes place in the four larger cells or macromeres, and, as indicated in Fig. 2, the direction of cleavage is shown to be in a right-handed spiral by the inclination of the spindles — just the reverse of the corresponding cleavage in the unreversed type. The cleavage of the egg was not followed beyond this point, but it is very probable that the subsequent divisions would show the same reversal. In Physa, according to Crampton, every division as far as the twenty-eight-cell stage is the reverse of the corresponding division in the closely allied genus Lymnea, and in Planorbis, in which I have followed the cleavage in detail to beyond the 150-cell stage, the reversed type of cleavage holds, except in one or two divisions, as far as the cleavage is of a determinate spiral character.

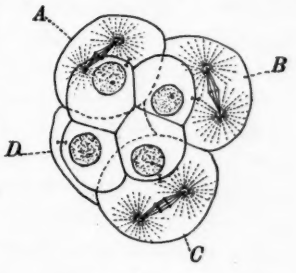

FIG. 1. — Eight-cell stage seen from the animal pole.

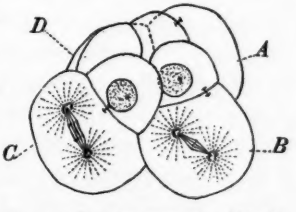

FIG. 2. — The same egg seen obliquely, showing the dexiotropic inclination of the spindles in the dividing macromeres. The cell *C* has begun to elongate.

It is one of the striking features of the cleavage of many mollusks and annelids that certain cells of the upper side of

the egg become so arranged as to produce the appearance of a cross, the center of which lies at the apical pole. It was found by Conklin that the arms of the cross in Crepidula are not exactly meridional in position, but have a slight dexiotropic twist. This twist Conklin considered as an expression of the dexiotropic cleavage of the egg, and the fact that the same inclination of the arms of the cross has been found by Heath in Ischnochiton, a form with the same type of cleavage, tends to confirm this view. In Planorbis, on the other hand, the inclination of the arms of the cross is very plainly læotropic, and this twist may be seen as late as the end of the period of gastrulation. A careful comparison of the genesis of the arms of the cross in these forms would convince any one, I believe, that the different directions of the inclination of the arms is correlated with the different types of cleavage. As a result, therefore, of reversed cleavage a considerable portion of the embryo becomes subjected to a torsion in a direction different from that which occurs in the normal forms. It does not seem possible in Planorbis to connect directly this torsion of the cross with the sinistral organization of the animal, for this structure disappears before the asymmetry of the embryo is manifest. However, the fact that reversal of cleavage shows its effects as late as the gastrula stage lends considerable support to the view that it may stand in some causal relation to the reversed asymmetry of the adult.

In Crepidula, Conklin has succeeded in tracing the beginning of the asymmetry of the embryo to the division of one of the cells of the entoderm. The time and direction of this cleavage were found to give the initial twist to the rudiment of the intestine. "If," says Conklin, "the initial asymmetry is caused in Physa, as in Crepidula, by the asymmetry of the cells *5C* and *5D*, then it is easy to see how this reversal of cleavage stands in a causal relation to the reversed asymmetry of the adult." In Planorbis the corresponding divisions result in the formation of very small cells instead of large, yolk-laden ones, as in Crepidula, and do not seem to exercise any influence in determining the asymmetry of the embryo. The cells of the entoderm become very numerous (over thirty) and of small size

before gastrulation occurs, and it seems impossible to connect the asymmetry of the adult with any of their divisions. The læotropic inclination of the arms of the cross in Planorbis is probably the expression of a torsion that affects, to a certain extent, a large part of the segmented ovum, and the reversed asymmetry of the adult may depend upon this general twist, rather than the reversed division of any of the cells of the entoderm. It is not improbable that the asymmetry of the animal may first manifest itself, as the results of various investigations indicate, in different parts of the embryo in different forms.

The reversal of cleavage in Ancylus has, I believe, a special significance from the fact that the left-handedness occurring in this genus has, in all probability, arisen independently of that of Physa and Planorbis. It may, indeed, be doubted whether the reversed asymmetry of the latter genera is due to their descent from a common sinistral ancestor; but, however this may be, it is scarcely possible that Physa, Planorbis, and the sinistral species of Ancylus all belong to one group which branched off from the dextral species of Ancylus and the other pulmonates. As is well known, we have sinistral individuals occurring as occasional variations among dextral forms, and in the genus Fulgur and in several genera of the terrestrial pulmonates there are well-established dextral and sinistral species. Analogous reversals of asymmetry occur in other groups of animals, such as the flounders, certain nematodes, and many crustaceans, and there appears to be no great improbability, *a priori*, in supposing an independent origin of left-handedness in Ancylus; besides, any other supposition would involve us in improbable phyletic derivations. The chance that the association of reversed cleavage with reversed asymmetry in the gasteropods is a mere coincidence is very much lessened by the circumstance that the same association obtains where the reversed asymmetry has been independently acquired. It would be a matter of interest to ascertain if the cleavage of the dextral species of Ancylus were of the normal type, and if the right-handed and left-handed species of Fulgur and the terrestrial pulmonates, Pupa, Bulimnus, and

Clausilia, have respectively a normal and reversed cleavage. So far as the facts are known at present, they seem to justify the view that the reversed asymmetry of the sinistral gasteropods owes its origin to a reversal of cleavage of the egg.

UNIVERSITY OF MICHIGAN,
October 13, 1899.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

V. Fresh-Water Ostracoda.

C. H. TURNER.

The Ostracoda form a well-defined division of the Entomostraca. They resemble the Lamellibranchiata in having the body enclosed in a bivalve shell. This peculiarity, which causes many a novice to mistake the Ostracoda for small Mollusca, is merely a superficial resemblance; for, although the structure of the enclosed animal is quite primitive, yet it is decidedly crustacean.

The body always bears seven pairs of articulated appendages. The first five of these are head appendages; but, in different groups, either one or all of the last three pairs of these cephalic appendages may be modified for locomotion. The last two pairs belong to the body and are usually known as feet. In some cases (Cypris), however, the last pair of feet is not used for locomotion. In most cases the abdomen terminates in a pair of appendages which resemble legs.

Handicapped by a comparatively heavy shell, the Ostracoda make, as a rule, very poor swimmers. Near the surface in deep waters these creatures are rare. Shallow ponds and marshes are their favorite haunts, but they are also found in rivers and at or near the bottom of lakes. Comparatively speaking, some forms swim quite well (Cypria, Cyclocypris, Cypridopsis), while others do not swim at all, but creep along the bottom or up the stems of plants, or else burrow in the mud or sand (Erpetocypris, Candona).

In the South, specimens may be collected at almost any time of the year, but the spring and fall are the best collecting seasons. In the North they may be collected from early spring to late fall, but spring and fall seem to be the best collecting seasons.

The literature of the Ostracoda is legion, but all known American fresh-water forms are described and figured in the following publications. The first two also contain a fairly complete bibliography up to 1896.

HERRICK, C. L., and TURNER, C. H. Synopsis of the Entomostraca of Minnesota, Copepoda, Cladocera, and Ostracoda. *Geol. and Nat. Hist. Survey of Minn.* 1895.

SHARPE, R. W. Contribution to a Knowledge of the North-American Fresh-Water Ostracoda included in the Families Cytheridæ and Cyprididæ. *Bull. Ill. State. Lab. Nat. Hist.* Vol. iv. 1897.

TURNER, C. H. A Male *Erpetocypris barbatus* Forbes. *Zoöl. Bull.* Vol. ii, pp. 199–202. 1899.

In compiling the following key free use has been made, not only of my own manuscript notes and published papers, but also of the published works of Brady, Vávra, and Sharpe.

The key includes all fresh-water genera known to me, whether they occur in America or not. An attempt is made to incorporate all known American species. A few European forms not yet found in America are included. All such forms are marked with an asterisk (*).

KEY FOR THE DETERMINATION OF THE AMERICAN FRESH-WATER OSTRACODA.

A. Second antennæ unbranched . . . . . PODOCOPA

AA. Second antennæ two-branched.

B. One branch rudimentary and immobile . . MYODOCOPA*

BB. Both branches developed.

C. Basal portion of the first antennæ geniculate, and the branches of the second antennæ flattened PLATYCOPA*

CC. Basal portion of the first antennæ not geniculate, and the branches of the second antennnæ not flattened CLADOCOPA*

TRIBE PODOCOPA.[1]

A. Last pair of legs bent backwards within the shell and not used for locomotion . . . . . CYPRIDIDÆ (I)

[1] The marine genera Aglaia, Argillœcia, Anchistrocheles, Cyprois, Paracypris, and Pontocypris are not included in this key.

* Contain no fresh-water forms.

AA. Last pair of legs directed downwards and used for locomotion.
B. Mandibles slender and styliform . . . PARADOXOSTOMIDÆ*
BB. Mandibles not styliform and toothed at the extremity.
C. Second maxillæ pediform.
D. Caudal rami obsolete, forming two rounded, setiferous lobes . . . . . CYTHERIDÆ (II)
DD. Caudal rami well developed but small . BARDIIDÆ*
CC. Second maxillæ not pediform but provided with a pediform palp . . . . . DARWINULIDÆ (III)

I. FAM. CYPRIDIDÆ.

A. Second foot terminates with a cylindrical joint that bears two backwardly directed setæ.
B. Second foot of both male and female six-jointed. No branchial plate attached to the second maxillæ . . Notodromas 11
BB. Second foot of the female usually five-jointed and of the male six-jointed. The second maxilla bears a branchial plate.
C. Branchial plate feebly developed in the form of two pectinated setæ.
D. Eye present . . . . . Candona 1
DD. Eye absent . . . . . Typhlocypris 15
CC. Branchial plate developed in the form of three pectinated setæ . . . . . Candonopsis 2
CCC. Branchial plate developed in the form of six pectinated setæ.
D. Palp of second maxilla rudimentary Ilyocypris 10
DD. Palp of second maxilla normally developed.
E. Terminal joint of the second foot one third as long as the fourth joint or shorter Cypria 4
EE. Terminal joint of the second foot two thirds as long as the fourth joint . . Cyclocypris 3
AA. Second foot terminates with a beak-shaped joint that bears one backwardly directed claw.
B. Caudal rami rudimentary.
C. Flagellum-like . . . . . Cypridopsis 6
CC. With lamellar base and long seta . Potamocypris 12
BB. Caudal rami normally developed, cylindrical, terminating in two claws.
C. Natatory setæ of the second antennæ not reaching to the base of the terminal claws . . . . . Scottia 13

CC. Natatory setæ of the second antennæ reaching to the base, but not to the tips of the terminal claws; claws of abdominal rami smooth or feebly denticulate Erpetocypris 9

CCC. Natatory setæ of the second antennæ reaching to or slightly beyond the tips of the terminal claws.

D. Dorsal setæ of caudal rami rudimentary or absent and the terminal claws of the abdominal rami coarsely denticulate . . . . Stenocypris 14

DD. Dorsal setæ of caudal rami normally developed.

E. Parthenogenetic . . . . . Cypris 8

EE. Sexual . . . . . Cyprinotus 7

BBB. Caudal rami exceedingly large and elongated, natatory setæ of both pairs of antennæ well developed, palp and masticatory lobe of first maxillæ narrow . . . . . Cypricercus 5

1. Candona Baird, 1850.

Antennæ of female five-jointed, of the male six-jointed. Natatory setæ absent. Two characteristic sensory setæ occur between the fourth and fifth joints of the second antennæ of the male. Branchial plate of the second maxilla composed of two unequal pectinated setæ, which are attached to the basal portion of the maxilla. The palp of the second maxilla of the female is two-jointed and terminates with three pectinated bristles; of the male is unjointed and differs in shape from that of the female. Second foot either five- or six-jointed, terminating in two unequally long, backwardly directed setæ and one forwardly directed seta. Caudal rami strong, bearing two terminal claws, the dorsal seta of the ramus usually quite remote from the claws. At the origin of the rami the dorsum of the body terminates in a short seta. Eye small. Males usually more common and larger than the females. Seven rows of chitinous spines arranged around the central cylinder of Zenker's organ. Cannot swim, but creeps along the bottom, or burrows in the mud or sand.

a. One of the shorter setæ of the tip of the second foot sharply reflexed . . . . . *C. reflexa* Sharpe

aa. Setæ at the tip of the second foot not reflexed.

b. Length of shell about 1.50 mm., shell inequivalve, second foot six-jointed . . . . . *C. crogmani* Turner

bb. Length of shell between 0.90 mm. and 1.25 mm.

c. Caudal rami curved, second foot six-jointed.

d. Terminal claws of caudal rami stout *C. fabæformis* Fischer

dd. Terminal claws of the caudal rami slender, spines on the first mandibular process of first maxilla not toothed.

e. Color white . . . . . *C. acuminata* Fischer
ee. Color greenish yellow variegated with blotches of brown . . . . . *C. delawarensis* Turner
cc. Caudal rami not curved.
d. Terminal claws of rami S-shape . *C. sigmoides* Sharpe
dd. Terminal claws not S-shape, the longest one-half as long as the ramus . . . . . *C. recticauda* Sharpe

2. Candonopsis Vávra, 1891.

Second antennæ similar to those of Candona. Mandible bears an extraordinarily long palp. Branchial plate of the second maxilla composed of three plumose bristles. Caudal rami slender, usual dorsal seta absent.

No species of this genus has yet been found in America.

3. Cyclocypris Brady and Norman, 1889.

First antennæ seven-jointed. Second antennæ five-jointed in female, six-jointed in male, no olfactory organ on the fourth joint. Natatory setæ of the second antennæ reach far beyond the tips of the terminal claws. Palp of both the mandible and first maxilla normally developed. The second maxilla bears a branchial palp and a plate. This branchial palp in the female is unjointed; in the male it forms a hooked prehensile organ. Last joint of second foot unusually long, being two thirds the length of the fourth joint. Zenker's organ resembles the corresponding organ of Cypria. Vas deferens long and convoluted, copulatory organ quadrangular. Males numerous.

a. Front edge of caudal ramus about twice as long as its terminal claw *C. lævis* O. F. M.
aa. Front edge of caudal ramus about two and a half times the length of the terminal claw.
b. Terminal claws of caudal rami strong and much bent *C. forbesi* Sharpe
bb. Terminal claws of caudal rami slender and not bent *C. modesta* (Herrick)
aaa. Front edge of caudal ramus about three times the length of the terminal claws. Terminal claws strong, nearly straight, weakly bent near the tips . . . . . *C. globosa** Sars

4. Cypria Zenker, 1854.

Second antennæ of the female five-jointed, of the male six-jointed. Distal extremity of the fourth joint of the second antenna bears two olfactory setæ. Natatory setæ of the second antennæ extend far beyond

the tips of the terminal claws. Mandibular palp much elongated. Palp of the first maxilla strongly developed. Second maxilla bears a well-developed branchial plate. In the female the palp of the second maxilla is unjointed and terminates in three setæ; in the male it forms a hooked prehensile organ, and the right and left palp of the male are dissimilar. Caudal rami are robust and the dorsal setæ are situated about midway of the outer border. Eye large. Muscle impressions four. The center of Zenker's organ surrounded by seven whorls of chitinous setæ. The upper part of the organ forms a blind sac, the lower terminates in the funnel-shaped origin of the vas deferens. Copulatory organ triangular. Males numerous.

a. Terminal short setæ of the second foot approximately equal.
  b. Terminal short setæ of the second foot about two times the length of the last joint. Left valve with a dorsal flange; right valve with row of tubercles anteriorly and ventrally
    C. pustulosa Sharpe
  bb. Terminal short setæ of the second foot about as long as the terminal joint.
    c. Terminal claw of the caudal ramus half the length of the ramus.
      d. Shell equivalve.
        e. Covered with a close reticulum of subparallel lines. Length 0.54 mm. to 0.64 mm.
          C. exculpta (Fischer)
        ee. Covered with irregularly scattered large puncta. Length 0.55 mm. to 0.58 mm.
          C. ophthalmica (Jurine)
    cc. Terminal claw of caudal ramus three fifths the length of the ramus or longer.
      d. Shell inequivalve, valves glossy, finely pubescent. Length 0.46 mm. to 0.52 mm.
        C. inequivalva Turner
      dd. Shell equivalve, surface smooth, sparsely hairy. Length 0.69 mm. . . . . *C. dentifera* Sharpe
aa. Terminal short setæ of the second foot evidently unequal.
  b. Shell covered with numerous almost confluent puncta. Length 0.78 mm. . . . . *C. mons* (Chambers)
  bb. Shell not especially marked in any way. Dorsal seta of ramus three times the width of the ramus from the terminal claws
    C. obesa Sharpe

5. Cypricercus Sars, 1895.

"Natatory setæ of both pairs of antennæ well developed; palp and masticatory lobe of the first maxillæ narrow. Caudal rami excessively developed and elongate, affording a ready means of recognition. Cœcal

appendage of the intestine unusually short; ovarian tubes much elongated." [Sharpe.] No American species known.

6. Cypridopsis Brady, 1867.

The first antenna is seven-jointed, the second five-jointed. The five natatory setæ of the second antenna are long and plumose. The branchia of the second maxilla consists either of a plate bearing five plumose setæ or else of two setæ inserted directly on the blade. Second foot five-jointed, bearing at its extremity a strong chitinous claw. Caudal rami rudimentary, flagellum-like. Parthenogenetic.

a. Branchia of second maxilla with five setæ. Shell marked with three more or less transverse, dark bands, which are confined to the dorsal and lateral surfaces. Very plump. Common. Length 0.54 mm. to 0.70 mm. . . . . *C. cypridopsis* (O. F. Mueller)

aa. Branchia of the second maxilla formed of two setæ.

b. Caudal ramus cylindrical and turgid, suddenly narrowing to a bristle . . . . . *C. newtoni* Brady and Robertson

bb. Caudal ramus broad, gradually narrowing to a bristle.

c. Natatory setæ of the second antennæ reaching to the tip of the terminal claws. Shell pale green *C. viliosa* (Jurine)

cc. Natatory setæ of the second antennæ reaching beyond the end of the terminal claws. Shell grass green on dorsal aspect . . . . . *C. smaragdina* Vávra

7. Cyprinotus Brady, 1885.

Shell rather thin, compressed, oval or subtriangular, height exceeding half the length, dorsal margin strongly arched, ventral aspect straight. Valves usually unequal, the left overlapping the right. The free edges of the left valve smooth, cephalic and caudal edges usually bordered with a hyaline flange. The free cephalic edge of the right valve usually armed with tuberculiform teeth. Natatory setæ of the second antennæ reach beyond the tips of the terminal claws. Caudal rami slender with smooth or very finely pectinated claws. Propagation sexual. Copulatory organs small, with an outer linguiform obtuse plate. The cylindrical core of Zenker's organ bears numerous wreaths of spines.

a. Length more than three mm.; color bluish white, with a group of scattered, large, sordid, yellowish punctures about the middle of each valve . . . . . *C. grandis* Chambers

aa. Length between one and two mm.

b. Dorsal seta of caudal ramus more than half the length of the subterminal claw.

c. Dorsal seta the width of the ramus from the subterminal claw. Terminal claw of second foot nearly straight *C. pellucida* Sharpe

cc. Dorsal seta at least twice the width of the ramus from the subterminal claw. Terminal claw of the second foot strongly curved . . . . . *C. incongruens* Ramdohr

bb. Dorsal seta of caudal ramus not more than half the length of the ramus.

c. Dorsal seta the width of the caudal ramus from the subterminal claw. Shell yellowish brown, marked with bluish black longitudinal stripes on the dorsum and sides, covered with coarse hairs, shell thin *C. burlingtonensis* Turner

cc. Dorsal seta of the caudal ramus twice the width of the ramus from the subterminal claw. Color yellowish green, shell reticulated with contorted lines which are most distinct on the cephalic portion of the valves. Shell thin *crena* Turner

8. Cypris O. F. Mueller, 1785.

Second antennæ five-jointed, natatory setæ extending to the tip of the terminal claws. Mandibular palp not extending beyond the tip of the mandibular teeth, the first mandibular process armed with two biarticulate thorns. Branchial plate of the first maxilla large, bearing stiff, plumose setæ. Second maxilla provided with a branchial plate. Caudal rami stout. Parthenogenetic.

a. Length three mm. or more.

b. Both spines on the first mandibular process of the first maxilla smooth, dorsal margin of shell strongly convex. Marked with dark bands . . . . . *C. herricki* Turner

bb. Both spines on the first mandibular process of the first maxilla toothed, dorsal margin of shell nearly straight marked with dark bands . . . . . *C. perelegans* Herrick

aa. Length between one and two mm.

b. Both spines on the first mandibular process of the first maxilla smooth.

c. Terminal claw of the second foot as long as the last joint. Shell noticeably less than three times as long as high.

d. Caudal ramus straight; subterminal claw two thirds as long as the terminal. Shell four ninths as high as long . . . . . *C. clavata* Baird*

dd. Caudal ramus weakly S-shaped.

e. Subterminal claw of the caudal ramus half as long as the terminal. Shell two thirds as high as long . . . . . *C. virens* Jurine

ee. Subterminal claw of the caudal ramus nearly as long as the terminal. Shell half as high as long *C. altissimus* Chambers

cc. Terminal claw of the second foot twice as long as the terminal segment. Shell fully three times as long as high. Subterminal claw of the caudal ramus half as long as the terminal . . . . . *C. fasciata* O. F. Mueller*

bb. Both spines on the first mandibular process of the first maxilla toothed.

c. Shell not reticulated with broken lines.

d. Shell less than twice as long as high, terminal claw of the caudal ramus half as long as the ramus.

e. Subterminal claw of caudal ramus three fourths as long as the terminal . *C. testudinaria* Sharpe

ee. Subterminal claw two thirds as long as the terminal *C. fuscata* (Jurine)

dd. Shell more than twice as long as high. Terminal claw of the caudal ramus one third as long as the ramus. Subterminal claw two thirds as long as the terminal *C. fischeri* Lilljeborg*

cc. Shell reticulated. Terminal claw of the caudal ramus nearly three fifths as long as the ramus, terminal seta not more than one fourth as long as the terminal claw *C. reticulata* Zaddach

aaa. Length between two mm. and three mm., third and fourth joints of the first foot fused . . . . . *C. pubera* O. F. Mueller*

9. Erpetocypris Brady and Norman, 1889.

General characters of the animal closely approaching those of Cypris; but the natatory setæ of the second antennæ do not reach nearly to the tips of the terminal claws, and they are not plumose. Second maxilla bears a branchial plate. Cannot swim, creeps along the bottom. Most forms parthenogenetic, some sexual.

a. Length about four mm. Claw on the last joint of the second foot seven-eighths as long as the last segment. Dorsal seta of the caudal ramus serrate and claw-like, close to the subterminal claw; dorsal edge of ramus finely toothed; ramus twenty times as long as wide; terminal seta about one third as long as the subterminal claw. Shell twice as long as high, the upper margin nearly straight *E. barbata* (Forbes)

aa. Length between two and three mm.

b. Claw on last joint of the second foot as long as that joint, shell about twice as long as high. Caudal ramus about ten times as long as wide, dorsal margin finely toothed *E. strigata* (O. F. Mueller)*

bb. Claw of last joint of the second foot three times as long as the last segment. Dorsal edge of caudal ramus armed with five combs of teeth . . . . . *E. reptans* (Baird)*

aaa. Length between one mm. and two mm.

b. Dorsal setæ of caudal ramus transformed into a short spine or claw, situated near the subterminal claw. Shell seven thirteenths as high as long . *E. olivacea* (Brady and Norman)

bb. Caudal ramus with only the terminal claws developed, lacking both the terminal and dorsal setæ. Shell two and a half to three times as long as high . *E. minnesotensis* (Herrick)

10. Ilyocypris Brady and Norman, 1889.

Shell oblong, with a transverse median depression, coarsely punctate and tuberculate. Second antennal setæ non-plumose, few; reaching a little beyond the apex of the terminal claws. Mandible palp four-jointed, with a setose branchial appendage. First pair of maxillæ composed of four segments, and a large branchial appendage bearing numerous terminal and about five reflexed basal setæ. Second pair of maxillæ consisting of a conical lobe, which bears numerous short marginal setæ, at the apex four stout plumose setæ, and at the base an appendage of four radiating plumose filaments and a biarticulate process bearing three apical setæ, one of which is plumose. The penultimate joint of the second foot has two marginal setæ; the last joint three long apical setæ, but no claw. Caudal rami ending in two long and equal claws and one very short seta, marginal seta long, and attached near the middle of the ramus. No American forms known.

11. Notodromas Lilljeborg, 1853.

Shell of male and female unlike. Second antennæ of both male and female six-jointed, natatory setæ extending beyond the tips of the terminal claws. No branchial plate on the second maxilla; palp of same two-jointed in the female; in the male the terminal segment forms a scythe-shaped appendage. Second foot five-jointed, abdominal ramus long and slender. Eyes two, separate. Males numerous.

a. Shell subquadrangular, surface smooth and shining. In the female, the caudo-ventral angle of the shell terminates in a horizontal, backwardly projecting, squamous, spine-like plate *N. monacha* (O. F. Mueller)

12. Potamocypris Brady, 1870.

Second antennæ four-jointed; natatory setæ numerous but short, not reaching beyond the middle of the terminal claws; last joint with two

strong terminal claws and two or three short, slender setæ. Mandible stout, palp three-jointed, with a single branchial seta near the base. Feet as in Cypris, caudal rami rudimentary, consisting of a long seta, with a lamellar base bearing a short seta which is usually situated near the base of the lamellar portion. Shell compressed. No American forms known.

13. Scottia Brady and Norman, 1889.

Shell not unlike that of the tumid forms of Cypris. Natatory setæ of the second antennæ extremely short, not reaching the base of the terminal claws. Limbs short and stout; claws of the caudal rami very stout, short, and twisted. No American forms known.

14. Stenocypris Sars, 1889.

Natatory setæ of the second antennæ not reaching beyond the tips of the terminal claws. Palp of the first maxilla very narrow, cylindrical, the last joint small, the masticatory lobes long and narrow. Caudal rami large, rather lamelliform, dorsal edges occasionally pectinate; claws very unequal, both coarsely denticulate; setæ of dorsal edge absent or small, apical seta long. Parthenogenetic. Shell narrow, height much less than half the length. No American forms known.

15. Typhlocypris Vejdovsky, 1882.

Second antennæ five-jointed in the female, six in the male. Natatory setæ of the second antennæ lacking. No eyes. Branchial plate of the second maxilla composed of two unequal plumose seta. No American forms known.

II. Cytheridæ.

Limnicythere Brady, 1868.

Shell strong, irregularly tuberculate or spinous. First antennæ five-jointed, with short bristles on their outer edge. Branchial plate of the mandibles strongly developed. Caudal rami rudimentary, usually only two short bristles. Males rare.

a. Terminal segment of first antenna seven times as long as wide. Second antennæ not especially armed in male. Rudimentary caudal rami cylindrical, about three times as long as wide *L. reticulata* Sharpe

aa. Terminal segment of the first antenna four to five times as long as wide. Second antenna of the male has its terminal claw armed with three or four strong teeth. Rudimentary caudal rami six to seven times as long as broad . . . . *L. illinoisensis* Sharpe

III. Darwinulidæ.

Darwinula Brady and Robertson, 1870.

Shell smooth, thin, and fragile. First antennæ short, stout, five- or six-jointed, strongly armed with stout, short setæ. Second antennæ stout, composed of four or five joints, no natatory setæ, no poison gland or urticating setæ. Mandible palp three-jointed, the basal joint large and densely setiferous. First maxilla bears a large branchial plate; the second a small branchial plate and a pediform palp. Post-abdominal rami subconical, small.

a. First antennæ composed of six joints, the second antennæ of four. Antepenultimate joint of the second antenna does not bear a conspicuous one-jointed appendage. Length 0.8 mm.

D. stevensoni Brady and Robertson *

aa. First antennæ composed of five joints, the second of five. Antepenultimate joint of the second antenna bears a conspicuous one-jointed appendage, which terminates in one long and one short filament. Length 0.68 mm. to 0.70 mm.

D. improvisa Turner

REVIEWS OF RECENT LITERATURE.

GENERAL BIOLOGY.

Natural Science and Philosophy. — Borntraeger Brothers[1] announce the programme of a series of chapters in popular knowledge by Dr. Adolf Wagner. The series is entitled *Studies and Sketches in Natural Science and Philosophy*, of which Nos. I and II have already appeared. The first of the series, Concerning Scientific Thinking and Popular Science, stands as a methodological introduction to the whole group by its discussion of the attitude of the logical thinker and of the process and results of epistemological analysis. After a discrimination of empirical investigation from critical reflection, in which the ease of the former and the difficulties which lie in the way of the latter are pointed out, the author goes on to indicate the nature of scientific thinking in general.

It is not any body of truth, or any form of expression, or any method of inquiry, — in so far as method means the employment of specific scientific instruments, — it is not the investigation of any particular problem or group of problems. Scientific thinking can be characterized only as an intellectual attitude, a method applicable to all possible subjects of investigation. It is, in short, sincere, critical thought, which admits belief only as it is based on evidence. Theoretical science, says the author, has attained no higher example than the canons of logical thought. It is criticism as opposed to dogma. Dogmatism remains dogmatism even when it speaks the phrases of science, and science, if it is sincerely to fulfil its office, must be kept free from the very taint of dogma.

This critical attitude of the thinker once made clear, an epistemological analysis of the nature of experience is entered upon in a series of discussions concerning things and properties, succession and connection in experience, cause and effect, laws and processes, reality and phenomena. The reader is then prepared to take up in detail the criticism of experience, of which the first aspect treated is the freedom of the will (No. II).

[1] Wagner, Dr. Ad. *Studien und Skizzen aus Naturwissenschaft und Philosophie.* I. Ueber wissenschaftliches Denken und populäre Wissenschaft. II. Zum Problem der Willensfreiheit. Borntraeger Bros., Berlin.

The style is easy, direct, and colloquial, and expresses a consistent endeavor after the utmost simplicity of statement and freedom from all technical terminology. One might call these booklets "guides to scientific thinking," in short words with easy illustrations, for their burden is told as to a child and the reader is *du-und-diched* throughout. Withal, however, the arrangement is clear and the exposition good, and the striving after simplicity is induced by a sense of the great impediments which the untrained thinker must meet in dealing with all profound critical problems. For the object of these studies is not to make known new facts to the reader but to stimulate him to logical reflection, not to furnish the memory but to arouse independent thinking. The world is fond of a phrase, for thinking is burdensome, and there are many technical terms on the lips of the reading public which have filtered through the magazines and popular books from scientific writings and are facilely employed but ill-understood. Evolution, mechanism and teleology, heredity and Darwinism, egoism, freedom of the will, — these phrases clothe the most significant problems of science and philosophy. The moment a new thought, a successfully daring speculation is represented in a phrase the imitative herd seizes upon it and bandies it glibly about, with commonly the most inadequate grasp of its meaning. To arouse a candid reflection upon such terms, to make the reader honestly attempt an analysis and comprehension of them for himself is the aim of these little books.

The following chapters of the series are already announced: Evolution in Nature; Heredity and Darwinism; On the Freedom of the Will; The Philosophy of Egoism; Mechanism and Organism; Instinct; On *a priori* Knowledge; The Division of Labor; On Positivism in Natural Science; The Mechanics of Evolution; Morals and Intellect.

ROBERT MACDOUGALL.

ZOÖLOGY.

Emery's Zoologia. — The last fifteen years have been characterized by the appearance of an unusual number of good zoölogical text-books. Most of these works have first appeared in German, French, or English; Emery's[1] *Compendium of Zoölogy* is in Italian. The field covered

[1] Emery, C. *Compendio di Zoologia.* vii + 456 pp., 600 illustrations and a map. Bologna, Nicola Zanichelli, 1899.

by these books has been so thoroughly worked over that any new effort in this direction could hardly be expected to possess great novelty and would naturally differ from its predecessors only in details. Emery's book is conventionally divided into a general part, of some hundred pages, devoted to the principles of zoölogy, and a special part, of over three times this length, containing a descriptive classification of the animal kingdom.

In the special part the Protozoa and Metazoa are recognized as primary divisions. The term radiates (zoöphytes) is resurrected to include the sponges, cœlenterates, and ctenophors; all the remaining Metazoa are placed in the group Bilateralia. This includes the worms (under which are placed the Platyhelminthes, worms proper, molluscoids, and Enteroptneusta), the echinoderms, the mollusks, the arthropods, and the chordates. The innovations in classification so far as they affect the larger divisions are brought about chiefly by the fusion of what were formerly considered separate groups. This seems to us to make for unnaturalness in the classification; thus it is very improbable, as in fact the author admits, that the group of worms as constituted above is a homogeneous assemblage, and the division Bilateralia is in a similar way still less justifiable.

The general part, which, so far as it goes, is well written, naturally offers a much greater opportunity for individualizing the book. It is prefaced by a short historical account in which the foreigner is struck by the translations of familiar names, such as Giovanni Mueller and Carlo Darwin. Then follows a brief but well-written chapter on protoplasm, its activities, the cell, direct and indirect division, etc. A brief treatment of histogenesis and organogenesis is followed by an account of the architecture of the metazoan body and a discussion of radial and bilateral symmetry, of metamerism, and of the laws of homologies. The significance of the individual and the formation of colonies are then dealt with. Reproduction is the title of the next chapter. Protozoan and metazoan reproduction are comprehensively compared, and such topics as sexual reproduction, parthenogenesis, alternation of generations, and heredity are considered. The evidences and consequences of evolution conclude the general part. This is perhaps the best chapter in the book, and the happy selection of Italian examples and illustrations makes it enjoyable reading even to the mature zoölogist.

While the general part compares very favorably with the corresponding portion of other works, it has two obvious deficiencies —

the almost total lack of any comparative physiological and histological statements. The absence of the former may be in part justified by the disorganized condition that the science of comparative physiology is still in, but no such excuse can be urged for comparative histology, which has already received good treatment in several text-books.

To a foreigner the text seems generally free from typographical errors, though occasional misprints, as Crincidi for Crinoidi (p. 217), are to be noticed. The text justifies a much better letterpress, and it is to be regretted that so many of the figures are spoiled by poor printing. In the map illustrating the zoögeographic regions (p. 72) the areas designated by different kinds of shading are scarcely to be recognized, and while many well-known islands have apparently sunk below the surface, numerous small archipelagoes of printer's ink have made their appearance in unexpected quarters. On the whole, the book deserves hearty commendation and ought to exert a stimulating influence on the study of zoölogy in Italy.

G. H. P.

Jordan's Manual of Vertebrates. — An eighth edition of this work is just issued from the press of A. C. McClurg & Co., Chicago. In it the nomenclature is brought to date, that of the fishes in an appendix, that of reptiles and birds by changes in the plates, and that of the mammals by a rewriting of the text. In the latter group special assistance has been given by Mr. T. S. Palmer of Washington, and in the reptiles by Dr. Leonhard Stejneger and others.

The volume now contains condensed descriptions of 1149 species of vertebrate animals native to the northeastern United States and arranged in 610 genera. Since the first edition in 1876 great changes have taken place in the nomenclature of these animals, not half the species retaining the scientific name then recognized.

All these changes have been, however, in the direction of stability of nomenclature, and the specific names in twenty-nine cases out of thirty are now permanently fixed by the law of priority.

Generic names must always vary with different views of convenience in the valuation of groups. Unfortunately they still fluctuate through variations in the methods employed in the restriction of the collective groups of the older authors.

The book is well printed, and the binding has improved with each consecutive edition.

Envelopes of the Spinal Cord. — Sterzi has studied this subject from a comparative standpoint (*Anat. Anz.*, Bd. XVI, p. 230) and points out that in the fishes there is but a single envelope proper, the meninx primitiva. In the Amphibia two meninges are developed, a meninx secundaria and a dura mater, separated by a series of lymph spaces. In the mammals these are represented by the three well-known membranes. In development the various meninges are developed from a single meninx primitiva by the formation of lymph spaces. Above the dura is an epidural space, whose lateral walls are formed by the so-called "Kalkorgan," a membrane with numerous cavities, containing crystals of calcic carbonate, but which is not to be considered as one of the true envelopes of the cord. The endorhachis is a strong fibrous membrane which serves as the periosteum of the spinal canal.

Origin of Mammals. — In the discussion on the origin of the mammals[1] recently held at the fourth international congress of zoölogy, Professor Seeley stated as his opinion that the anomodonts were not ancestors of the mammals, but that both groups had a common ancestor to be sought for in rocks earlier than the Permian. The forms thus far discovered, however, show so close a connection between reptiles and mammals that it is not reasonable to believe that future discoveries will seriously alter this assumed connection. Professor Osborn believed that much of the resemblance between reptiles and mammals was due to parallelism and pointed out that the mammal egg was more amphibian than reptilian in character. If the ancestor of the mammal was a reptile it was one that retained certain amphibian characters. Professor Marsh expressed the opinion that none of the fossil reptiles thus far known could be said to be a satisfactory ancestral representative of the mammals and suggested the origin of this group from primitive amphibians. Professor Haeckel argued for the monophyletic origin of placental mammals from one marsupial ancestor. Mr. Sedgwick thought the question of the origin of mammals was possibly insoluble from the facts that embryological evidence is not sufficiently conclusive and that the paleontological remains are too fragmentary. Professor Hubrecht defended the view that mammals may have had a polyphyletic origin and raised the question whether mammals other than monotremes had descended from oviparous ancestors.

G. H. P.

[1] The Origin of Mammals, *Proc. Fourth Internat. Congress Zoöl.*, pp. 68–75. 1899.

Placenta of Tarsius and of Tupaja. — Professor A. A. W. Hubrecht[1] has made a careful study of the placentas of Tarsius and of Tupaja to determine whether these organs are centers for the formation of blood corpuscles (hæmatopoetic organs). He concludes that blood corpuscles are produced on both the maternal and embryonic sides of the placenta and that many of the corpuscles which are produced from embryonic tissue make their way into the maternal circulation. The bearing of this on questions of telegony is obvious, though it must not be forgotten that in some mammals this kind of blood formation does not occur. G. H. P.

Uterus masculinus of the Rabbit. — Professor Ramsay Wright[2] confirms Kölliker's statement that the so-called *uterus masculinus* in the rabbit is formed from the fused caudal ends of the Wolffian ducts and not from the Müllerian ducts as might be inferred from its name. The organ then is not homologous with the vagina of the female nor with the *uterus masculinus* in man. G. H. P.

Fossil Hyracoid. — Professor H. F. Osborn[3] has described a new species of fossil Hyrax, *Pliohyrax kruppii*, from the Lower Pliocene of Samos. The specimen is interesting in being the only well-established fossil remains of this peculiar group. G. H. P.

Bipedal Lacertilia. — Mr. W. Saville-Kent[4] has collected evidence on bipedal locomotion among existing lizards and finds that it may be assumed by the following species: *Chlamydosaurus kingi*, *Physignathus leseuri*, *Amphibolurus muricatus*, *Agama stellio*, *Teguexin americanus*, *Ameiva surinamensis* (according to Mr. H. Prestoe), and *Basiliscus americanus* (W. F. H. Rosenberg). Presumably this habit has been inherited from some such ancestor as the extinct bipedal Dinosauria. G. H. P.

[1] Hubrecht, A. A. W. Ueber die Entwickelung der Placenta von Tarsius und Tupaja, *Proc. Fourth Internat. Congress Zoöl.*, pp. 345–411, 12 pls. 1899.

[2] Wright, R. On the So-called *Uterus masculinus* of the Rabbit, *Proc. Fourth Internat. Congress Zoöl.*, p. 185. 1899.

[3] Osborn, H. F. On *Pliohyrax kruppii* Osborn, a Fossil hyracoid, from Samos, Lower Pliocene, in the Stuttgart Collection, *Proc. Fourth Internat. Congress Zoöl.*, pp. 172, 173, 1 pl. 1899.

[4] Saville-Kent, W. Bipedal Locomotion among Existing Lizards, *Proc. Fourth Internat. Congress Zoöl.*, pp. 168, 169. 1899.

Lateral Fins of Fishes. — Professor W. Salensky[1] has given a brief but important report on the development of the lateral fins of fishes. According to Gegenbaur, the lateral fins of fishes are derived from modified gill arches, and the fish in which the most primitive form of fin occurs is Ceratodus. Professor Salensky has studied the development of the lateral fins in the sterlet and in Ceratodus. In the pectoral fin of the sterlet the fifth to the tenth myotome produce muscle buds which give rise to the musculature of the fin. Myotomes posterior to these also give rise to buds which, however, abort. The fin rays do not produce basalia by the fusion of their proximal ends, but rays and basalia come from a common blastema. In Ceratodus the sixth to the tenth myotome contribute muscle buds to the fin. The skeleton of the fin appears in the form of a single rod of cartilage and the rays bud out from it without reference to the muscle buds. The rays are comparable with the secondary rays, not with the ordinary rays of the fish fin. The cartilage axis of the fin is homologous with one of the basalia. As the muscles of the Ceratodus fin arise as in other fishes, it is fair to assume that the Ceratodus fin is not a primitive fin, as Gegenbaur believed, but is a greatly reduced fin of the ordinary type. These facts in large measure destroy the slight support that Gegenbaur's archipterygium theory formerly had.

G. H. P.

The Chiasma of the Optic Nerves of the Amphibia has been studied by Franz Fritz (*Jen. Zeit.*, Bd. XXXIII, p. 191), both by microscopic and by degeneration methods. His most important result is that there is a total crossing of the optic nerves. Professor Kölliker has lately confirmed several of the results of Ramon y Cajal as to the existence of numerous unilateral and direct fibres in the chiasma of certain mammals (*Verhandl. Anat. Ges.*, Bd. XIII, 1899), and the fact that in some cases fibres divide in the opticus, and the two branches go to the two tracts.

Eigenmann on the Blind Fish of the Caves. — One of the most valuable contributions yet made to the literature of Organic Degeneration is a paper entitled "The Eyes of the Amblyopsidæ," being the first of a series on "The Eyes of the Blind Vertebrates of North America," by Dr. Carl H. Eigenmann. It is published in Roux's

[1] Salensky, W. Zur Entwicklungsgeschichte des Ichthyopterygiums, *Proc. Fourth Internat. Congress Zoöl.*, pp. 177–183. 1899.

Archiv für Entwickelungsmechanik der Organismen, seventy-two pages, with six plates, part of them colored, and ten figures in the text.

In this memoir Dr. Eigenmann describes the degraded condition of the eyes in the six known species of the Amblyopsidæ, three of them (*Chologaster cornutus*, *C. papilliferus*, and *C. agassizii*) with small but developed eyes, and three, *Amblyopsis spelæus*, *Typhlichthys subterraneus*, and *Troglichthys rosæ*, being blind. The blind species are not very close to one another, and each must have been independently derived from eyed forms. Typhlichthys is descended from Chologaster, the others from genera now extinct.

After an exhaustive study of the anatomical details, Dr. Eigenmann takes up the causes of the degeneration of the parts of the eye, and their replacement in the orbit by masses of fat. He considers in detail the theory that the organ diminishes with disuse (ontogenic degeneration) and that the effect of disuse appears to some extent in the next generations (phylogenic degeneration).

A second theory is that of panmixia, the cessation of selection in which the general average falls progressively the birth average as maintained in selection.

A third is a reversed action of natural selection, by which the organ degenerates through the migration of those with good eyes to the light, or through their extermination on account of the waste in weight or nutrition, or through injury to the useless eye.

Still another view is that of the struggle of the parts either for room or for food. By this the unused eye may be crowded out or starved.

Another view refers the degeneration of the organ to a struggle between soma and germ to produce the maximum efficiency of the former with the minimum expenditure of the latter.

Or again we may suppose that the result follows, through germinal selection, the struggle of the representatives in the germ.

Dr. Eigenmann calls attention to the fact that while we ought to consider, first, the causes of individual generation and, second, the processes or causes which led to its transmission, practically it is impossible to do so. Again the eye is itself a complex organ, and when each of its parts loses its utility, the degeneration progresses unequally. His final conclusion is, that "the condition of the eyes in the blind fishes can only be explained as the result of the transmission of *disuse* effect." The eye (functional) of Chologaster is symmetrically reduced from a larger normal fish eye. The retina is the

first structure simplified. Later the lens and especially the vitreous body degenerated more rapidly than the retina. The muscles in Typhlichthys have disappeared. The scleral cartilages have not failed to the same extent as the active structures of the eye. The degeneration is in no case due to arrested development. D. S. J.

Abbott on the Marine Fishes of Peru. — An excellent piece of faunal work is "The Marine Fishes of Peru," by James Francis Abbott, published in the *Proceedings of the Academy of Natural Sciences of Philadelphia* for June, 1899.

The paper is based on the collections made by Rear-Admiral L. A. Beardslee, U. S. N., at Callao, while in command of the *Philadelphia*. This accomplished officer has long taken a deep interest in natural history matters, and this collection presented by him to Stanford University is a proof of such interest.

Mr. Abbott notes 102 species as recorded thus far from Peru, and thirty of them are included in the Beardslee collection. Mr. Abbott describes as new the following species from Callao: *Basilichthys octavius*, *Basilichthys regillus*, *Basilichthys jordani*, *Pisciregia beardsleei*, and *Sciæna gilberti*. The new genus Pisciregia is allied to the California genus Atherinopsis, having a similar non-protractile premaxillary, but the vomer is armed with recurved teeth; the outer teeth in the jaws are enlarged, and the first dorsal is very small. The abundance of species of large-sized Atherinidæ (Pez del Rey), constituting the genera Chirostoma, Atherinopsis, Atherinops, Basilichthys, and Pisciregia, excellent food fishes all, is one of the notable features of the fish fauna of the eastern Pacific. D. S. J.

Fishes of French Guiana. — Dr. Léon Vaillant has published in the *Bulletin* of the Museum at Paris a paper on fishes collected in French Guiana, mostly from fresh waters.

Two new species are described: *Arius physacanthus*, from Rio Mahury; and *Rivulus geayi*, from Rio Cachipour. The Arius is allied to *emphysetus* and should be placed with it in Sciadeichthys if the modern genera of Bleeker are adopted. D. S. J.

Australian Tunicata. — Students of the Tunicata have known for some years that Professor W. A. Herdman has been occupied with the investigation of the collections of this group belonging to the Australian Museum at Sydney, New South Wales, and his report has

been looked forward to with interest. After a considerable delay, due to the late financial depression in Australia, the work has now been published as *Catalogue No. XVII* of the Museum. That it is of the highest order of scientific excellence hardly needs to be said, particularly for those who are familiar with Professor Herdman's distinguished work in the past on this group of animals.

The author has entitled his report a "Descriptive Catalogue of the Tunicata in the Australian Museum, Sydney, New South Wales," and he says that it is not to be regarded as a monograph on Australian Tunicata. He tells us that he was expressly enjoined by the trustees of the Museum "not to enter into anatomical and histological details beyond what he considered necessary for the elucidation of the systematic position and the sufficient description of the various species." The fact, consequently, that he has devoted nearly one hundred large octavo pages and forty-two plates to the description of the sixty-two new species serves as an index to what this veteran ascidiologist believes to be the briefest treatment consistent with exactness in this group.

In his introduction he gives a brief discussion of classification and concludes that, despite the various quite radically different systems that have since been proposed, he sees no sufficient reason for departing widely from the one adopted by him in his *Challenger* report of 1882. And he justly remarks that he feels himself strengthened in his position by the fact that this system has been quite generally adopted by recent writers, notably by Seeliger in his "Tunicata" for Bronn's *Klassen und Ordnungen des Thierreichs.*

He does, however, introduce one modification of considerable importance. He divides the Ascidiæ compositæ into two sections, one of which contains the "compact-bodied families," Botryllidæ and Polystyelidæ, and the other the "remaining families with extended or divided bodies." For these he proposes to adopt the names "Holosomata" and "Merosomata," respectively, if Sluiter, who first used them, but in a somewhat different sense from that in which Herdman proposes to use them, will agree to Herdman's modification. Or if Sluiter refuses to accept this modification, then Herdman will adopt the terms "Pectosomata" and "Chalarosomata" for the respective groups.

There can be no doubt, particularly since the Polystyelidæ and Botryllidæ have been shown to agree so closely in their method of budding, that they should be associated more closely in classification than either family can be with the other families of compound ascid-

ians. I believe, however, that the point of similarity emphasized by Professor Herdman's proposal, *viz.*, the compactness of the body, is considerably less fundamental than some other characters that might be selected, particularly that of the method of budding. Furthermore, the term "Holosomata" does not apply to these two families any more than it does to Perophora, which genus the author does not, of course, associate with the Botryllidæ and Polystyelidæ.

I would not go so far as Garstang has in relying upon the character of the budding as a basis for classifying the compound ascidians, but I believe that in the present state of our knowledge the most natural grouping of them that can be made is into two sections. One of these would include those in which the buds arise directly from the body of the parent, and the other those in which the budding is from a stolon. The first section might well be called the "Somatoblastica" and the second the "Rhizoblastica." These sections would correspond to Herdman's, with the exception that it would remain for the present an open question as to which one should contain the Didemnidæ, the probabilities being, however, that this family would ultimately find its place among the Somatoblastica.

Those who object to mongrel words will be likely to find fault with "Pectosomata" on etymological grounds.

At the close of the report the author has given a list of all the species of Tunicata thus far known from Australian waters. This list includes 187 species, distributed as follows among the three divisions of the group:

Larvacea	1 species
Thaliacea	7 species
Ascidiacea	179 species

The work is a very important contribution to the general zoölogical knowledge of this group. Less can be said in favor of the volume from the bookmaker's than from the naturalist's point of view, but it will serve its purpose well, and that is the essential thing.

WM. E. RITTER.

The Coccidæ of Mauritius. — M. d'Emmerez de Charmoy has recently published a very interesting account of the Coccidæ of Mauritius, in a pamphlet issued by the Société Amicale Scientifique of that island. As it is probable that this work will not fall into many hands, it may be worth while to give a list of the species,

correcting the nomenclature at the same time, so far as seems necessary :—

Aspidiotus alæs simplex, n. var., p. 20.
A. articulatus simplex, n. var., p. 21.
A. tesseratus, n. sp., p. 23.
A. maskelli, Ckll., p. 24.
A. cyanophylli, Sign., p. 24.
A. lataniæ, Sign.
= *A. cydoniæ*, p. 25.
A. trilobitiformis, Green, p. 26.
Chrysomphalus aonidum, L.
= *A. ficus*, p. 25.
C. cladii, Mask.
= *A. cladii*, p. 22.
C. aurantii, Mask.
= *A. aurantii*, p. 22.
Parlatoria sp. ?
= *P. zizyphi*, p. 27.
Diaspis euphoriæ, n. sp., p. 28.
D. pentagona, Targ.
= *D. amygdali*, p. 29.
D. calyptroides cacti, Comst., p. 29.
Howardia biclavis, Comst.
= *Chionaspis biclavis*, p. 30.
Chionaspis dilatata, Green, p. 31.
C. sp. ?
= *C. quercus*, p. 30.
C. tegalensis, Zehnt., p. 31.
Mytilapsis hibisci, n. sp., p. 32.
M. greeni, n. sp., p. 33.
M. beckii, Newm.
= *M. citricola*, p. 34.
M. gloveri, Pack., p. 35.
Fiorinia fioriniæ, Targ.
= *F. camelliæ*, p. 37.
F. cockerelli, n. sp., p. 37.
F. alæodendri, n. sp., p. 36.
Aonidia (?) *allaudi*, n. sp.
= *F. allaudi*, p. 35.
A. (?) *allaudi galliformens*, n. var.
= *F. a. galliformens*, p. 36.
Vinsonia stellifera, Westw., p. 38.
Ceroplastes vinsoni, Sign., p. 38.
Lecanium oleæ, Bern., p. 39.
L. hemisphæricum, Targ., p. 40.
L. hemisphæricum filicum, Boisd., p. 40.
L. longulum, Dougl., p. 40.
L. nigrum, Nietn., p. 40.
L. tessellatum, Sign., p. 40.
L. viride, Green, p. 41.
Pulvinaria cariei, n. sp., p. 41.
Asterolecanium bambusæ, Boisd., p. 42.
A. miliaris, Boisd., p. 42.
A. pustulans, Ckll. ?
= *A. quercicola* ?, p. 42.
Oudablis sp. ?
= *Phenacoccus nivalis*, p. 42.
Dactylopius calceolariæ minor, Mask., p. 44.
D. virgatus, Ckll., p. 44.
D. filamentosus, Ckll.
= *D. vastator*, p. 45 (fide Tinsley).
D. sacchari, Ckll., p. 45.
D. citri, Risso, p. 45.
D. longispinus, Targ.
= *D. adonidum*, p. 46.
= *D. pteridis*, p. 46.
Orthezia insignis, Dougl., p. 46.
Icerya seychellarum, Westw., p. 47.
Chætococcus bambusæ, Mask.
= *Sphærococcus bambusæ*, p. 48.

Thanks to M. de Charmoy, the writer has been able to examine some of the new species. The *Mytilaspis hibisci*, unfortunately not figured, is close to *M. crawii*, but easily distinguished by the dark scale. The *Aonidia* (?) *allaudi* is a beautiful and singular thing, and could be considered the type of a new genus. *Aspidiotus tesseratus* is not a Diaspidiotus, as M. de Charmoy has it, but a Pseudaonidia. Singularly enough, it was found almost simultaneously, by Professor C. H. T. Townsend, at Coatzocoalcos in Mexico, and described by the present writer under a different name, which latter,

now in press, will be withdrawn. The identity of *Dactylopius vastator* with *D. filamentosus* was lately discovered by Professor J. D. Tinsley, who is about to publish an article on the subject. *Euphoria longana*, the plant on which *Diaspis euphoriæ* was found, is properly a Nephelium.

T. D. A. COCKERELL.

The Corpora allata of the Orthoptera. — Heymons describes (*Sitzber. Preuss. Akad. Wiss.*, 1899, Nr. 30) two small bodies, the corpora allata, lying immediately above the œsophagus in the head of *Bacillus rossii*. At first sight they appear as if they were a second pair of pharyngeal ganglia of the sympathetic system, as they lie immediately above the paired visceral nerves. Sections, however, show that, while they lie on these nerves, they are non-nervous in structure. They are vesicular in nature, composed of a single layer of columnar epithelium, the cavity of the vesicle being filled by a stratified chitine, apparently molted by the epithelium. In development these corpora arise as ectodermal ingrowths from the ventral surface, on the boundary between the mandibular and maxillary segments. From these ingrowths a pair of small cell masses, at first solid, bud off and gradually pass dorsally to the definitive position. Concerning the function of these structures, which have been seen in Hymenoptera and other forms by other students, Heymons has little definite to offer. Experiments by extirpation of the structures from living insects showed that they apparently are not organs of equilibration, while the absence of sensory hairs would seem to suggest that they are not sensory in structure. The absence of ducts and of concrements and excretory granules in the protoplasm would militate against a glandular nature. The suggestion is made that they were originally peripheral organs and that, with their migration to an internal position, they have lost their primitive significance.

Systematic Position of the Fleas. — Dr. Heymons, in a short paper (*Zool. Anz.*, Bd. XXII, p. 223), gives his opinions upon this mooted question. He claims that Kräpelin's views of the homologies of the mouth parts are erroneous, there existing in all stages a labrum, and a pair each of mandibles and maxillæ, the latter with palpi and a labium. The wounds produced by these animals are not caused by the upper lip, but by the mandibles which are worked by two protractors and two retractors. Anatomical structure goes to show that these forms are to be regarded as forming a distinct order (Siphonaptera), and that Puliciphora, often considered as an annectent form

on the dipteran side, is a true fly of the family Phoridæ, without any siphonapteran affinities.

The Sting of the Hymenoptera. — Zander has studied the structure of the sting in sixty-two hymenopterous insects and, among other conclusions (*Zeit. wiss. Zool.*, Bd. LXVI, p. 289), comes to the support of the views of Heider, Heymons, and Kulagin, that the elements of the sting (*i.e.*, the gonapophyses) are not homologous with the other appendages. This conclusion is based on the fact not only that these structures arise much later than the abdominal legs, but that they arise in a position nearer the middle line than do the transient abdominal limbs.

Nematodes. — Dr. O. von Linstow[1] has just published the results of his studies on the parasitic nematodes of the Berlin Zoölogical Collection. The paper is altogether the most extensive contribution to this much neglected and little known group that has appeared in recent years. It includes descriptions of forty-nine species, of which thirty-eight are new to science. Among them the genus Ascaris was represented by twelve species, and Filaria by nine, while the other species were distributed through numerous genera, two of which, however, were entirely new. These forms were collected from every continent except North America and were taken from hosts in every group of vertebrates.

Among items of general interest was noted the abundant occurrence in fish of ascarid larvæ, often of considerable size, whereas *Ascaris lumbricoides*, the human round worm, of which the life history is known, undergoes direct development, *i.e.*, has no intermediate host.

A striking form is the new genus Pterocephalus from the intestine of the zebra in east Africa. The head of the adult parasite bears six conical spines, six hooks, and six deeply serrated leaf-like appendages which are attached only at their constricted bases. While the hooks and spines are directed anteriad, these appendages lie prone and reversed; when, however, the mouth opening is drawn in and the spines and hooks inverted and concealed, the appendages are turned anteriad and project from the anterior margin of the head curiously like wings, hence the generic name. These structures are wanting or only faintly indicated in the immature forms.

Spiroptera (an *Filaria*) *bicolor*, previously reported by von Linstow

[1] Linstow, O. von. Nematoden aus der Berliner Zoologischen Sammlung, *Mitth. a. d. Zool. Samml. d. Mus. f. Naturk. Berlin*, Bd. i, Hft. 2 (1899), 28 pp., 6 pls.

from a German catfish, appeared again from a fresh-water fish of Australia. Another unexpected discovery was a new species of Syngamus, the gap worm of fowls. This new form occurred in the choana of a deer from Rio Grande do Sul, and in the nasal cavity of a goat from Cameroon. Only one other species of this genus occurs in the Mammalia : *Syngamus dispar* in the trachea of *Felis concolor.*

This paper constitutes the second number of a new series of publications from the Museum für Naturkunde, Berlin ; the management of the museum is certainly to be congratulated on the admirable form in which the series is being published.

Movements of Pseudopods. — M. Eugène Penard has recently published[1] an account, rather too brief, of his observations "sur les mouvements autonomes des pseudopodes."

The results of most interest may be summarized as follows (they relate chiefly to *Difflugia lebes* Penard): —

1. If a severed pseudopod be removed from the parent to a distance not more than two or three times the diameter of the shell of the parent, it will, after having remained in a globular, motionless condition for a short time, extend itself toward the parent, and finally reach it and become fused with it, the junction with the parent usually being at the latter's mouth.

2. If the original point of contact is not at the parent's mouth, the returning pseudopod moves along the shell of the parent until it reaches this point.

3. When the returning pseudopod comes very near the parent, the latter usually extends one of its own pseudopodia toward it, and this particular paternal process becomes larger than the others.

4. The absorption of the detached pseudopod by the parent is not an act of digestion and assimilation, as is proved by the fact that the fragment is not taken into a vacuole of the parent, nor into its interior in any way; and by the further fact that the act of absorption is fully accomplished in a much shorter time than is required for a true digestion.

5. Severed pseudopodia are attracted neither by one another nor by foreign bodies of practically the same size as the parent.

6. If a different individual Difflugia, of the same or of another species, be placed near an amputated pseudopod, the latter not only will not be attracted toward the former but will actually move away from it.

W. E. R.

[1] *Archives des Sciences physiques et naturelles*, Mai, 1899, pp. 434–445.

Notes. — *Nectonema agile* has been reported by Pintner (*SB. math.-natw. Cl. K. Akad.*, Wien, 13. April, 1899) from the Bay of Naples. In March a single specimen was collected and in May two others. As it is hardly credible that such a conspicuous form could have been overlooked hitherto, this sudden appearance so remote from the south shore of New England, the only locality from which it has heretofore been recorded, is certainly remarkable.

The cestodes of the Bergen Museum have recently been studied by Lönnberg (*Bergens Museums Aarbog*, No. 4, 1898). An extended study was made of Cœnomorphus, the peculiar tetrarhynchid larva of P. J. van Beneden. According to the author it departs widely enough from the typical tetrarhynchids to be regarded the representative of a new subfamily. Its anatomy is well illustrated, as also that of some other cestodes.

Gordii from Malaysia and Mexico are discussed by Camerano (*Atti Acc. Sci. Torino*, Vol. XXXIV, 1899). The two Mexican forms are species of the genus Chordodes.

The South African species of Peripatus are enumerated by Purcell (*Ann. of South African Mus.*, 1899), who describes seven distinct and one doubtful species. He accepts Pocock's subdivision of the genus Peripatus and includes the South African species in Peripatopsis and a new genus, Opisthopatus.

Maurer has placed considerable weight upon the distribution of the hair in embryo mammals as evidence for the derivation of hair from epidermal sense organs (see this journal, Vol. XXXI, p. 767). De Meijere has studied the subject and concludes (*Anat. Anz.*, Bd. XVI, p. 249) that this distribution affords little support for Maurer's views. In this connection it is to be noted that Kromayer (*Archiv für Entwickelungsmechanik*, Bd. VIII) describes the hair as having a dermal Anlage.

Negri has followed the processes described by Petrone for demonstrating the nucleus in the red-blood corpuscles in the mammals. He finds (*Anat. Anz.*, Bd. XVI, p. 33) that Petrone's methods (osmic acid, 1 : 4000; picric acid, 1 : 4000; formic acid carmine) give a differentiated central portion in the corpuscle. The same methods applied to the blood of embryonic mammals bring out a similar structure, while at the same time hæmatoxylin differentiates a true nucleus. Hence he concludes that Petrone's structure is not a true nucleus,

a conclusion which agrees well with what was previously known concerning the development of the red corpuscles.

Gustav Fornier points out (*Biol. Centralblatt*, Bd. XIX, p. 549) that the lizard, *Lygodactylus picturatus*, and several other species of the genus are provided with a sucking disk at the end of the tail, similar in structure to those on the toes.

BOTANY.

Colors of Flowers. — The author of this contribution [1] to the discussion of the origin and significance of color in flowers has evidently set out with a clearly defined purpose. In his preface he declares that he was not entirely satisfied with the soundness of the theories of Grant Allen and of Hermann Müller, whom he brackets together as authorities. Moved by this discontent, he investigated the coloration of many flowers (and of some other things), and this little work embodies his results.

Briefly stated, Mr. Hervey's conclusions are to the effect that Grant Allen's hypothesis in regard to the sequence of colors, namely, that yellow is the primitive color, and that white, red or purple, violet or blue are more highly evolved colors, is an untenable one. Müller's statements in regard to the preferences of certain insects for especial colors are taken up in some detail and considerable evidence is adduced in the attempt to show that insects are somewhat indifferent to color, and that many of them, honey bees for example, find very inconspicuous and partially concealed nectariferous flowers by "instinct." Bumblebees, by some inscrutable neglect of evolution or Providence, have unfortunately been left out in the distribution of this instinct and have to get along without it, making up, however, to some extent for the lack of it by the brutality with which they bite through corolla tubes and help themselves to nectar.

The author offers "as an original solution of the subject [of the origin of honey-guides]" the statement: "This richness of color [in Tropæolum] is occasioned by the irritating influences of the bees in traversing the same route to and from the nectary, thus stimulating the flower to send more of its peculiar pigment to this point, same

[1] Hervey, E. Williams. *Observations on the Colors of Flowers.* New Bedford, 1899. 8vo, 104 pp.

as a little friction or a pinch will bring the blood to the cheek and cause a rosy tint." Even the lay reader will find little difficulty in judging of the value of the analogy between the development of pigment in cells of petals and the response of human arteries to stimulation transmitted from the central nervous system.

It is hardly worth while to multiply instances of inaccurate and fanciful reasoning like the case just cited. Evidently Mr. Hervey is not versed in modern systematic botany or he would not say, "The Ranunculaceæ are placed first in order in our floras, we imagine for the reason that the flowers of this family are very simple in construction." If he is acquainted with the histology of the sepals and petals which he is discussing as regards their coloration, the fact does not appear in his pages. In short, he is not sufficiently equipped successfully to attack the very difficult problem of the nature and genesis of the colors of floral organs. If his labors should prove to be of use to the scientific investigator, it will be by his having collected and tabulated a considerable number of facts in regard to the distribution of color in flowers and the sequence of tints where there are progressive changes of coloration.

JOSEPH Y. BERGEN.

The Teaching Botanist.[1] — To those who have kept in touch with the changing conditions of secondary education during the last decade, it has become most apparent that there has been a steadily growing demand that greater consideration should be given to the natural sciences. Very possibly the numerous summer schools maintained by the various colleges have served to cultivate and strengthen this tendency, if they were not directly responsible for it in the first instance; and the large number of teachers who annually take the time set apart for a much-needed rest to qualify themselves further in some special subject affords ample evidence, not only of the gathering force of the demand, but also of the seriousness of purpose which underlies it. In no subject has this movement gained greater headway than botany, and if evidence of this fact were needed, it might be found in the numerous text-books and laboratory guides which have appeared within recent years, all directed toward supplying working force to the teacher who is not a specialist, and who is usually compelled to divide his or her time among several subjects.

It has long been felt that some unification of method would be in

[1] *The Teaching Botanist*, a manual of information upon botanical instruction, together with outlines and directions for a comprehensive elementary course, by W. F. Ganong, Ph.D. New York, The Macmillan Company, 1899. 270 pp.

the highest degree desirable, though extremely difficult of realization. The very timely work by Dr. Ganong, however, promises to bring this ideal much nearer than heretofore. In *The Teaching Botanist* he has brought together in convenient form the best experience of our leading botanists as to the place which botany should occupy, and the best methods of presenting it with the greatest educational effect. It is in no sense a text-book, but it may be more appropriately called a "teacher's guide," occupying a field distinctly apart from the usual text-book.

After noting that botanical teaching is in a state of very rapid expansion and transition, and the unprecedented demand for a teaching that shall be more extensive, more thorough, and more representative of the present state of science, the author discusses The Place of Botany in Education, What Botany is of most Worth, and Things Essential to Botanical Teaching — chapters which are rich in suggestive thought and well merit the careful perusal of every conscientious and enterprising teacher. Botanical Books and their Uses adds much to the value of the work.

The second part is devoted to The Principles of the Science of Botany, in which is given an outline of a series of studies, illustrated by simple experiments which are well within the range of ordinary school work, and for which apparatus of a very simple and inexpensive kind will suffice.

The work marks a distinct advance in school methods and should be in the hands of every teacher.

D. P. P.

Massee's Plant Diseases.[1] — In an introduction of fifty-three pages the author gives a short general account of fungi, the precautions to be used in preventing and combating diseases caused by them, and details concerning fungicides and spraying. The main part of the volume is devoted to descriptions of the principal diseases due to fungi in all parts of the world, giving the popular and scientific names, simple descriptions of the fungi and the effects they produce on the plants they attack, together with notes on the means of prevention as far as they are known. References are also given, to which the reader is directed for further information. The accounts of the special diseases follow the systematic order of the fungi which cause them, rather than the arrangement followed in some treatises where the

[1] Massee, George. *A Text-Book of Plant Diseases caused by Cryptogamic Parasites.* New York, The Macmillan Company, 1899. Small 8vo, xii + 458 pp., 92 figs.

different diseases which attack any particular plant are grouped together. The numerous illustrations are in general satisfactory. In some cases, as in that of *Phyllactinia suffulta*, they might be improved. The last hundred pages give the scientific descriptions of the fungi treated on previous pages. The *Text-Book* is one which will prove valuable to the student of plant diseases, and to the specialist it is important, since the diseases mentioned are not confined to those of Europe and North America, but include a large number of tropical diseases with regard to which the literature is scattered and often inaccessible. Whether the aim of the author, which, as stated in the preface, is to enable those directly occupied in the cultivation of plants, and with but a limited period of time available for study, to determine the nature of diseases caused by vegetable parasites, is likely to be accomplished seems to us doubtful. The general account of fungi, although good as far as it goes, does not give sufficient information as to the characters of the different orders of fungi and of their relation to each other to enable one who has not already some special knowledge of mycology to follow clearly the descriptions of the different diseases. The work, it seems to us, is adapted rather to those who already have some knowledge of systematic mycology, such as persons connected with agricultural schools and experiment stations, and for them the work is a valuable one.

Hough's American Woods.[1] — Part VIII of this unique series of sections of our native woody plants contains west American species of which, perhaps, the most unexpected are the castor bean, tree tobacco, mission cactus, and desert palm. The remainder of the species, however, are of more than usual interest, and one, the Christmas berry (*Heteromeles arbutifolia*), presents a graining of rare beauty. The descriptive text is preceded by useful flower, foliage, and fruit keys to all of the species thus far represented in the publication.

Notes. — A considerable illustrated paper on the anatomy of *Carludovica plicata* is contributed by Henri Micheels to the current volume of the *Mémoires* of the Société Royale des Sciences de Liége.

[1] Hough, Romeyn B. *The American Woods*, exhibited by actual specimens and with copious explanatory text. Pt. viii representing twenty-five species by twenty-five sets of sections. 8vo, viii + 66 pp. Cards of sections, 176–200. Lowville, N. Y., 1899.

Loesener has issued in separate form a paper entitled "*Plantæ Selerianæ*, die von Dr. Eduard Seler und Frau Caecilie Seler in Mexico und Centralamerica gesammelten Pflanzen," reprinted from recent numbers of the *Bulletin* of the Boissier Herbarium.

In a recently published address delivered in November, 1898, before the University of Catania, Professor P. Baccarini discusses the character and history of the Mediterranean flora.

Productive activity in the biological departments of most of the greater institutions of learning is becoming manifest in the increasing publication of the results of research work in the form of "contributions" and the like. The latest of these is the *Meddelanden från Stockholms Högskolas Botaniska Institute*, of which the first volume, for 1898, contains ten papers dealing with a variety of botanical subjects. Professor Lagerheim has done well for the preservation of these papers in binding them together with a collective titlepage and table of contents.

The very active botanical garden at Buitenzorg has recently commenced the publication of a new *Bulletin de l'Institut Botanique de Buitenzorg*, the first number of which contains interesting data on the organization and work of the garden.

An interesting catalogue of the trees and shrubs in the arboretum and botanic garden at the Central Experimental Farm, at Ottawa, Canada, is published by Dr. Saunders and Mr. W. T. Macoun as *Bulletin 2*, second series, from the Experimental Farm. It shows that of a total of 3071 named varieties which have been tested, 1434 have proved hardy, and 361 half hardy, while 737 have not been planted long enough to warrant an opinion as to their hardiness. With this list as a guide, residents of Canada and our Northern States should be able to increase the number of woody plants employed for the decoration of their grounds with a fair prospect of success.

The geographic source of the principal woody plants of the German trade is discussed by Professor Drude in the last volume of the *Jahresbericht* of the Dresden Society "Flora."

In an article recently published in the *Gärtnerisches Centralblatt* and translated for the September *Bulletin* of the Torrey Botanical Club, Dr. Kuntze argues for the adoption of 1737 as the starting point for generic names in botany, and 1753 for specific names, with

the future exclusion of all publications between Linnæus's *Genera Plantarum* of the former date and his *Species Plantarum* of the latter date.

The morphology, biology, and physiology of the flower of the great Amazon water lily, *Victoria regia*, are treated by Eduard Knoch, in Heft 47 of Luerssen and Frank's *Bibliotheca Botanica*.

A paper on the structure and biology of *Cynomorium coccineum* is reprinted by Baccarini from the *Atti* of the Accademia Gioenia, of Catania.

Three new grasses from North Carolina are described by Ashe in a recent number of the *Journal* of the Elisha Mitchell Scientific Society.

PALEONTOLOGY.

Fossil Medusæ.[1] — A few years ago no one would have suspected that the rocks of the world could ever yield fossil jellyfish sufficient in quantity to warrant the publication of a quarto monograph of 201 pages and forty-seven plates like the present volume. Equally unlooked for would have been the fact that the oldest known fauna, the Cambrian, was to furnish a large part of the species, together with a great abundance of specimens.

Dr. Nathorst of Sweden (1881) first described Medusæ from the Cambrian, and Walcott, in 1891, suggested that the long-known *Dactyloidites asteroides* of Fitch (*sp.*), from the Cambrian slates of New York, might indicate portions of fossil jellyfish. The true affinities of the puzzling Alabama "star-cobbles" were likewise determined by Walcott in 1893, so that gradually both the subject of fossil Medusæ and the material for study grew sufficiently large to necessitate a separate treatment.

The present volume gives a full review of all the known fossil organisms that are now referred to the Medusæ, including both casts and impressions of the body or parts of the animal, and certain trails or markings, such as could be made by dragging the arms or tentacles over the mud of the sea bottom.

[1] Walcott, Charles Doolittle. Fossil Medusæ, *Monographs of the U. S. Geological Survey*, vol. xxx, pp. i–x, 1–201, Pls. I–XLVII. Washington, 1898.

All the undoubted fossil species are classed with the Discomedusæ, and as Haeckel considers this suborder as genetically late in the history of the Acraspeda, their presence in the Cambrian indicates that the differentiation of the class into orders must have taken place in pre-Cambrian time.

There are seven species known from the Cambrian of the United States, Sweden, Esthonia, Russia, and Bohemia. A single species has been noted in the Permian of Saxony, and twelve forms have been described from the lithographic slates of Bavaria. These twenty species, together with two doubtful forms, are described with as much completeness of detail as the preservation of the specimens will permit. Their treatment, as a whole, furnishes the student with a valuable thesaurus of all the available knowledge on the group and a wealth of excellent illustrations.

For a long time the early name of Medusites of Germar (1826) was employed as a generic term to include all fossil jellyfish, but as the original specimens appear to belong to Lumbricaria, Walcott proposes the name Medusina to include all species the true generic character of which cannot be ascertained. Under this term three Cambrian, one Permian, and six Jurassic species are placed, thus leaving but ten species sufficiently well preserved to be satisfactorily defined and classified. Of these ten species six are from the Jurassic of Bavaria and are described under six generic designations. The remaining four species are from American Cambrian terranes and comprise *Brooksella alternata*, *B. confusa*, *Laotira cambria*, and *Dactyloidites asteroides*. The compound nature of Laotira is of unusual interest, especially some specimens of *L. cambria* and *D. asteroides* that indicate occasional reproduction by means of lateral fission. Among recent genera this process is extremely rare.

The giving to indeterminate and unknown markings, mostly inorganic, a binomial nomenclature is quite as productive scientifically as giving generic and specific names to fog and thunder. One such term is "Eophyton," described in 1868 as a plant with monocotyledonous affinities. It has since been enriched by a number of species. Nathorst was of the opinion that many of these fossils represented trails of Medusæ. Walcott concurs in this and supplements it by proving similar markings to be casts of trails of drifting Algæ in shallow water.

C. E. B.

PETROGRAPHY AND MINERALOGY.

The Characters of Crystals.[1] — "I have attempted, in this book, to describe, simply and concisely, the methods and apparatus used in studying the physical characters of crystals, and to record and explain the observed phenomena without complex mathematical discussions" (from author's preface).

The book is divided into three parts and fourteen chapters. The first part discusses the geometrical characters of crystals, the second part the optical characters, and the third part the thermal, magnetic, and electrical characters and those depending upon elasticity and cohesion. In an appendix of seven pages a laboratory course in physical mineralogy is outlined.

While there is nothing new in the presentation or in the subject-matter of the little volume, it nevertheless will be useful as a laboratory manual, since there are to be found in it very concise descriptions of all the methods usually made use of in determining the physical constants of crystals, and in recording the results of angle measurements. In order, however, that it may be of the greatest value to the student, the topics discussed in it should be preceded by a course of lectures in which the principles involved in the descriptions are explained in more detail than has been done in the book.

Many of the methods described are here presented for the first time in English, and for this reason, if for no other, the little volume should meet with a welcome in all mineralogical laboratories. W. S. B.

The First Appendix to the Sixth Edition of Dana's System of Mineralogy, by Edward S. Dana,[2] completes this great work to the beginning of the year 1899. It includes a list of the new mineral names that have been proposed since the *System of Mineralogy* appeared, descriptions of each of the substances indicated by these names, and an account of all the important additions to our knowledge of the species described in the large manual. A vast amount of information is included in the seventy-five pages of the Appendix, and all of it may be depended upon as being trustworthy.

The *System*, with the addition of the Appendix, probably constitutes the most complete summary of a science that exists in any language. W. S. B.

[1] Moses, Alfred J. *The Characters of Crystals. An Introduction to Physical Crystallography.* New York, D. Van Nostrand Company, 1899. viii + 211 pp., 321 figs.

[2] New York, John Wiley & Sons, 1899. x + 75 pp. Price, $1.00.

NEWS.

Dr. Wilhelm von Ahles, professor of botany in the technical school at Stuttgart, has resigned.

Dr. A. B. Meyer, director of the zoölogical and ethnological museums in Dresden, has been in this country studying museum construction and administration. He was sent by the Saxon government.

Mr. J. W. Hendric has given the California Academy of Sciences $10,000 to constitute a publication fund.

At the Marine Biological Laboratory at Woods Holl, Mass., during the past summer the attendance was as follows: investigators, 58; embryology, 21; morphology, 32; physiology, 9; botany, 26; a total of 146.

Recent appointments: Professor W. Branco, of Hohenheim, professor of geology in the University of Berlin. — Dr. Karl Josef Erich Cowens, professor extraordinarius of botany in the University of Tübingen. — Dr. Wilhelm Figdor, docent for anatomy and physiology of plants in the University of Vienna. — Frederick P. Gorham, assistant professor of biology in Brown University. — Dr. James L. Kellogg, of Olivet, Mich., assistant professor of biology in Williams College. — A. F. Stanley Kent, professor of physiology in University College, Bristol, England. — Albert B. Lewis, instructor in zoölogy in the University of Nebraska. — Annie Lyons, assistant in zoölogy in Smith College. — Dr. Johannes Meisenheimer, docent for embryology in the University of Marburg. — Dr. G. Sclavunos, professor of anatomy in the University of Athens. — Dr. Wilhelm Sklarek, editor of the *Naturwissenschaftliche Rundschau*, titular professor. — Dr. Felice Supino, assistant in the zoölogical laboratory of the University of Rome. — Ralph W. Tower, assistant professor of chemical physiology in Brown University. — Dr. Arthur Willey, lecturer on biology in Guy's Hospital, London. — Robert H. Wolcott, adjunct professor of zoölogy in the University of Nebraska. — Dr. Ernst Anton Wülfing, of Tübingen, professor of geology and mineralogy in the Agricultural Institute at Hohenheim.

Deaths: Perez Arcaz, entomologist, in Madrid. — Eugène Gonod d'Artemare, botanist, June 16, in Ussel, France. — Sigismondo Brogi, naturalist, in Siena, July 17, aged 48. — Dr. Karl Bernhard Brühl, formerly professor of zoötomy in the University of Vienna, in Graz, Austria, August 14, aged 79. — John Cordeaux, of Lincolnshire, ornithologist, August 1, aged 68. — Dr. George A. Hendricks, professor of anatomy in the College of Medicine of the University of Minnesota, September 24. — Dr. Oluf Rygh, professor of archæology in the University of Christiania, August 20, aged 66. — Johann Nep. Schnabl, mycologist, in Munich, June 16, aged 45. — Dr. Lawson Tait, well known for his investigations on insectivorous plants, in London, June 13, aged 55. — Dr. Friedrich Thiele, naturalist, in Lochwitz, near Dresden, August 16, aged 85. — Rev. William Farren White, entomologist, in Bournemouth, England, July 21, aged 66 years.

NOTE.

THE AMERICAN MORPHOLOGICAL SOCIETY will meet with the Society of American Naturalists and other affiliated Societies, at New Haven, during the Christmas holidays. The dates of the meetings are (unofficially) December 27–29. The titles of papers to be presented may be sent to the secretary, Prof. Bashford Dean, Columbia University, New York City.

PUBLICATIONS RECEIVED.

The regular exchanges of the *American Naturalist* are not included.

DANA, E. S. First Appendix to the sixth edition of Dana's System of Mineralogy, completing the work to 1899. New York, John Wiley and Sons, 1899. x, 75 pp., figures. — DAVENPORT, C. B. Statistical Methods with Special Reference to Biological Variation. New York, John Wiley and Sons, 1899. vii, 148 pp., figures. — KORSCHELT, E., and HEIDER, K. Text-book of the Embryology of Invertebrates. Translated from the German by Edward L. Mark and W. McM. Woodworth. Part i. Porifera, Cnidaria, Ctenophora, Vermes, Enteropneusta, Echinodermata. London, Swan, Sonnenschein & Co., Limited. New York, The Macmillan Company, 1895. xvi, 484 pp., 225 figs. $4.00. — KORSCHELT, E., and HEIDER, K. Text-book of the Embryology of Invertebrates. Translated from the German by Matilda Bernard. Revised and edited with additional notes by Martin F. Woodward. Vol. ii. Phoronidea, Bryozoa, Ectoprocta, Brachiopoda, Entoprocta, Crustacea, Palæostraca. London, Swan, Sonnenschein & Co., Limited. New York, The Macmillan Company, 1899. xvi, 375 pp., 165 figs. $3.00. — KORSCHELT, E., and HEIDER, K. Text-book of the Embryology of Invertebrates. Translated from the German by Matilda Bernard. Revised and edited with additional notes by Martin F. Woodward. Vol. iii. Arachnida, Pentastomidæ, Pantopoda, Tardigrada, Onychophora, Myriopoda, Insecta. London, Swan, Sonnenschein & Co., Limited. New York, The Macmillan Company, 1899. xii, 441 pp., 198 figs. $3.25. — NEWTON, ALFRED. A Dictionary of Birds. London, Adam and Charles Black, 1893–1896. Cheap issue, unabridged, published October, 1899. xii, 124, 1088 pp., cuts. $4.00. — PINCHOT, GIFFORD. A Primer of Forestry. Part i. The Forest. Bulletin No. 24 U. S. Department of Agriculture. Division of Forestry. Washington, 1899. 12mo, 88 pp., 47 pls. — THOMPSON, ERNEST SETON. The Trail of the Sandhill Stag. New York, Charles Scribner's Sons, 1899. 93 pp., 60 figs. $1.50.

(*No. 394 was mailed October 20, 1899.*)